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BICYCLE EFFICIENCY TESTS.

A DESCRIPTION OF THE METHOD OF TESTING, WITH A COMPARISON OF THE EFFICIENCY OF DIFFERENT TYPES OF BICYCLES UNDER VARIOUS CONDITIONS, AND THE RELATIVE EFFICIENCY OF SOLID, CUSHION AND PNEUMATIC TIRES.

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THE bicycle of to-day is one of the best examples that we have of evolution in connection with machine design.

For strength, combined with lightness, efficiency of power transmitting mechanism and durability of its parts, it stands in the front rank of engineering construction.

Yet so great has been the demand for this self-propelled vehicle, and so rapid its development from a mere toy to the present universal and invaluable means of locomotion, that only recently have any investigations been made of its actual strength and efficiency. A few of the principle manufacturers have for several years been in the habit of testing the material that went into their bicycles for strength and elasticity, and at least three of these have recently added to their laboratories apparatus by which they can make comparative tests of their efficiency as a means of propulsion.

The object of this paper is to describe the methods used, and to state some of the results obtained in this direction in the laboratories of Sibley College, Cornell University.

The tests made for efficiency of propulsion may be divided into two general classes; road tests and laboratory tests.

Road Tests.—These are made by actually riding the bicycle over the road, and measuring the power required to propel it by means of a transmission dynamometer attached either to the pedal or the crank. The speed and grade are also measured, and from the data thus obtained the proportion of the total work to that actually used in propulsioon is obtained.

This method has the advantage over the laboratory method that it gives an actual measurement of the total work put into the bicycle.

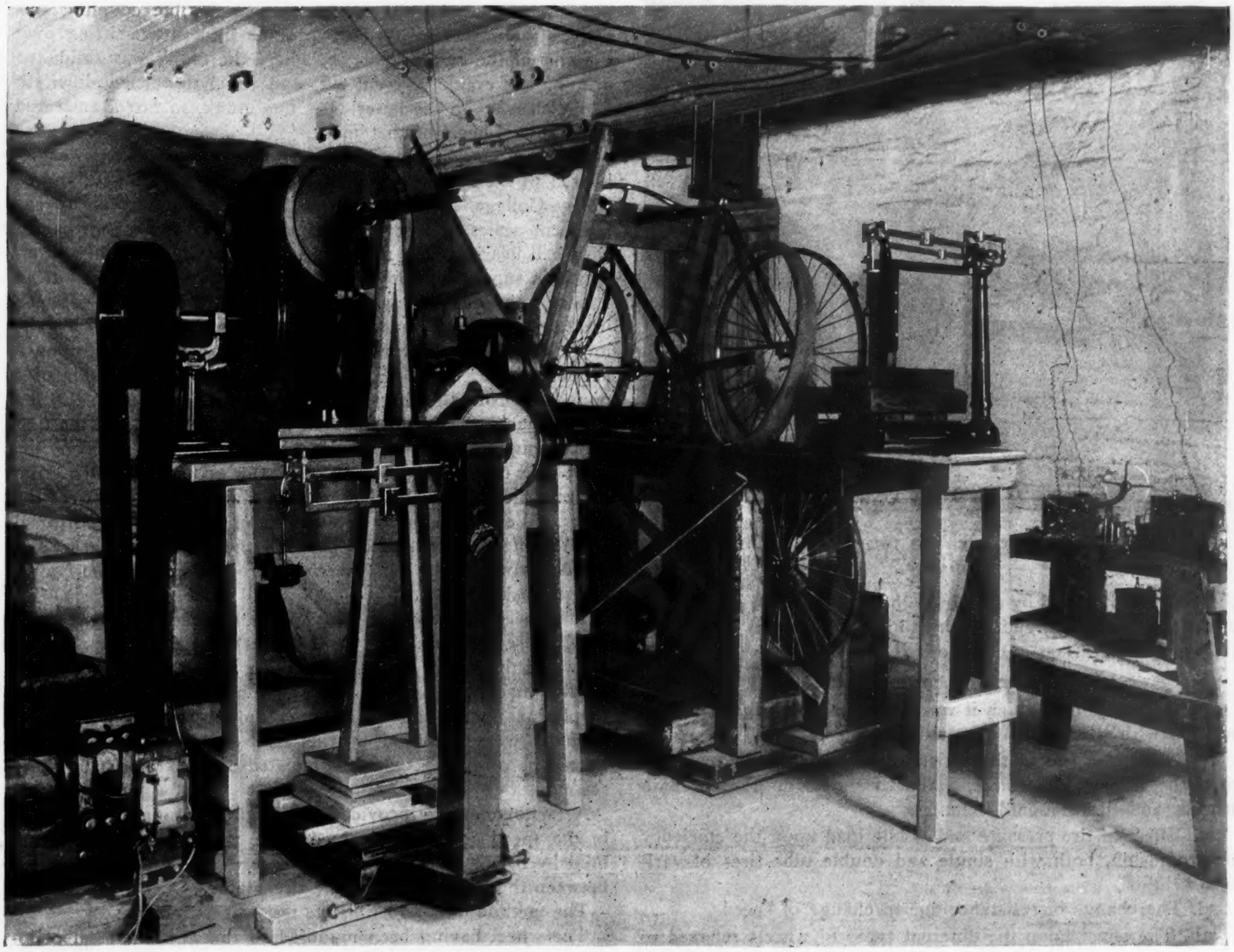


FIG. A. THE APPARATUS USED FOR THE BICYCLE TESTS.

The disadvantages are that it only gives this information for the actual conditions of road, rider and surrounding atmosphere conditions existing at the moment, and which are impossible to reproduce.

Laboratory Tests.—In these tests the rear wheel of the bicycle is supported upon the rim of another wheel directly under the bicycle wheel and in the same plane. This supporting wheel, called the track wheel, takes the place of the road bed, and by means of it the rear wheel of the bicycle can be driven from the crank shaft through the bicycle gearing at a speed of rotation corresponding to any speed of translation desired. An

absorption dynamometer is attached to the axis of the track wheel, and a transmission dynamometer to the bicycle crank shaft.

The advantages of this method are that the conditions of the test as to saddle load, tire pressure, speed and equivalent grade can be duplicated with different wheels and varied through a wide range.

The disadvantages are that the effect of different kinds of road bed, sand, rock, etc., cannot be introduced; the friction of the front wheel and of the pedal is eliminated; the effect upon the bearings of the crank shaft, due to the alternate thrust of the feet of the riders upon the opposite pedals is not obtained; and

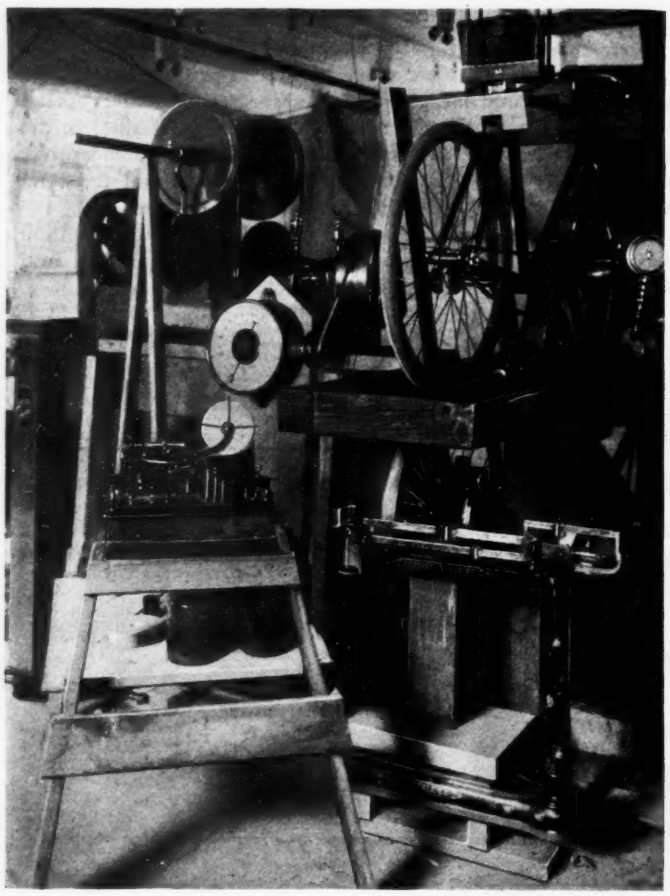


FIG. B. APPARATUS ARRANGED TO DETERMINE THE EFFECT OF PEDALING.

the resistance offered by the air to the movement of both wheel and rider through it, and which at high velocities is one of the largest factors of loss is not shown.

The Points to be Determined.

The special points which it was desired to investigate in connection with this article were as follows:

1st. A comparison of the resistance of the different types of modern safeties; viz., Racer, Standard and Drop Frame chain wheels, and the Standard chainless.

2d. Effect of tire pressure and saddle load upon the efficiency of propulsion, both with single and double tube tires of various weights.

3d. The change of resistance due to change of speed.

4th. The effect upon the different types of wheels referred to above of the alternate thrust upon the two opposite crank shaft bearings due to the action of pedaling.

5th. Whether or no a bicycle deteriorates by use.

6th. The relative efficiency of the solid rubber tire, the cushion tire and the pneumatic tire.

To insure that the wheels which were tested with the first object in view were of the same grade of material and workmanship, it was considered desirable that they be of the same make. This was assured through the kindness of Mr. F. J. McClune, a local bicycle dealer, who furnished four '98 model Crescents of the types mentioned above. For the comparison of new wheels with wheels that had been ridden, a '98 model Rambler was obtained from Mr. McClune, and two other Ramblers and a Crescent, all of which had seen considerable use, were borrowed from their owners.

Method of Testing.

The bicycle was mounted upon the testing frame, as shown in the cuts, so that its rear wheel rested upon the track wheel, and the center of the rear wheel and track wheel were in the same vertical line, both wheels lying on the same vertical plane. The front wheel of the bicycle was securely fixed to a post at the front end of testing frame, and suitable guides provided to keep the bicycle vertical, and still allow it to rise and fall with the irregularities of the tire. The track wheel consisted of an ordinary tandem bicycle wheel, with its ball bearings, but with the periphery of the felloe left flat, and 2¼ inches wide. An iron brake pulley was attached by the rim to the spokes of the track wheel, so as to revolve concentrically with it. The arm of the prony brake with which this pulley was provided, rested upon a pair of scales reading to fiftieths of a pound. A frame was attached to the seat post in which weights corresponding to the weight of the rider could be placed. The bicycle was driven by means of an electric motor through a countershaft, transmission dynamometer and universal coupling. The countershaft was provided, in order to reduce the speed from that of the motor to a speed suitable for the crank shaft of the bicycle. The universal coupling connecting the dynamometer with the bicycle crank shaft allowed the bicycle to move vertically without interfering with the driving. The flexible coupling was generally attached to the bicycle crank by a sleeve fitting over the end of the crank shaft, or, where the crank was solid, the arm of the crank was cut off, and the hub turned down to fit the sleeve. In the latter case, one crank, so fitted, answered for all the wheels of that make.

The transmission dynamometer which measured the power delivered to the bicycle was designed by Prof. W. F. Durand of Sibley College, and is shown in both cuts directly above the platform scales. It consists simply of two sheaves provided with ball bearings and mounted upon opposite ends of a lever, which is supported midway between the two sheaves upon an Emery knife edge, consisting of a thin, flexible strip of steel, whose plane is parallel to the planes of the two sheaves. A prolongation of this lever rests upon a knife edge carried upon a support resting upon a pair of scales reading to fiftieths of a pound. A round leather belt connecting a sheave upon the end of the countershaft with a similar sheave on the end of the universal coupling passes over the two dynamometer sheaves, the tight side of the belt passing vertically up to and down from the one sheave, and the slack side in a similar manner over the other. We thus have the pressure upon the scales proportional to the difference in tension between the tight and slack sides of the driving belt, and therefore proportional to the power transmitted.

The speed of the crank shaft of the bicycle and of the track wheel were determined by means of a Weaver electric register, shown at the left in Fig. B. This instrument recorded by electrical contacts made at the crank shaft and the track wheel each revolution upon a ribbon of paper moving at a uniform rate. Seconds were recorded at the same time upon the ribbon by means of a clock which completed an electric circuit every second.

A tachometer was provided by which instantaneous readings of the speed could be obtained. The tire pressure was measured by means of a drum with pressure gage attached inserted between the foot pump and the tire nipple.

The method of conducting the test was as follows:

The wheel having been mounted so that the universal coupling ran true and the rear wheel was vertically over, and tracked properly on the track wheel, the saddle load was applied by means of the weights, and the tire pumped to the required pressure. The flexible coupling was then disconnected, and the dynamometer scales made to balance at zero, while the dynamometer was running. It was found that change of speed did not affect this reading. The universal coupling was then put in place, and the test proper begun. The bicycle was first driven at various speeds throughout a range of from five to thirty miles an hour, with no brake attached to the rear wheel, the dynamometer scales balanced for each speed, and the tachometer read. These runs gave the power used in driving the bicycle with no resistance offered, save that of the track wheel, with its

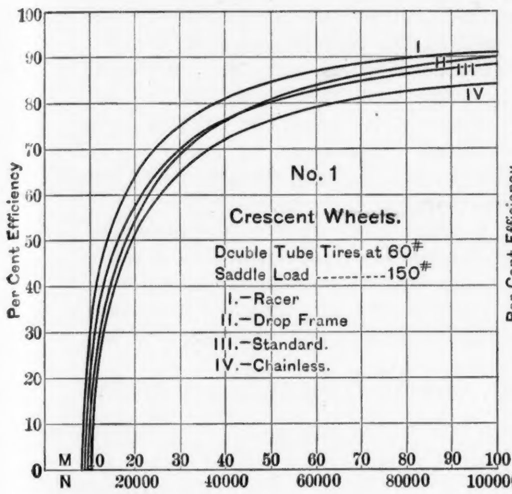
wind resistance. The resistance of the track wheel was measured once for all by supporting the bicycle so that its rear wheel was free from the track wheel, removing the tire of the rear wheel, and driving the track wheel from the rear wheel by a belt made of a piece of light twine. Dynamometer readings taken with this belt on and then off, gave us the power required to drive the track wheel.

To go back to the test itself. The track wheel prony brake was next put on, and the brake scales made to balance at the reading desired for the run, while the dynamometer scales were balanced, and the tachometer read. This operation was repeated for various speeds for each brake load. Runs were thus made for each condition of tire pressure and saddle load. Two or three readings of the electric speed register were taken for each brake load, in order to determine accurately the ratio between the speed of the crank shaft, and that of the track wheel. This make and supposed to be of the same grade, when attached to the same wheel, pumped to the same pressure, and carrying the same load, would vary several per cent. in efficiency. These facts made it apparent that in order to determine the comparative efficiency of the bearings, and power transmitting mechanism of different bicycles, it would be necessary to eliminate the tire resistance. This was done in the following manner:

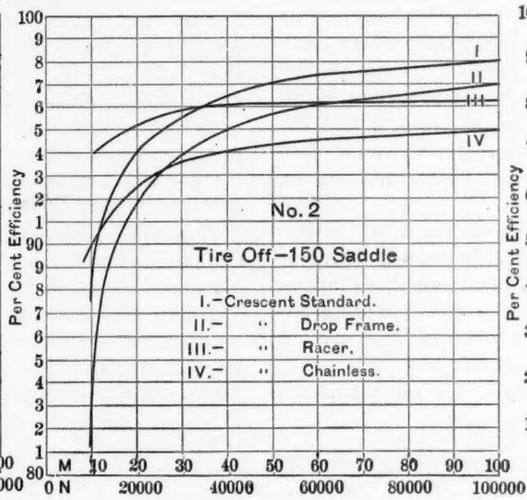
After making the runs previously described, the tire was removed and supports placed under the frame, as near the rear axle as posible, thus leaving the rear wheel free to revolve without touching the track wheel.

A rope brake was then wrapped about the felloe of the rear wheel, and attached to the same brake scales that were used in the test with tire on. Runs were then made in the same manner as before.

Cut A shows the apparatus arranged for this test.



M.--Equiv. Crank Pressure; 6½ in. Crank; 71 in. Gear.
N.—Gross Work per Mile. Ft. Pounds.
Speed, 10 Miles per Hour.



M.—Equiv. Crank Pressure; 6½ in. Crank; 71 in. Gear.
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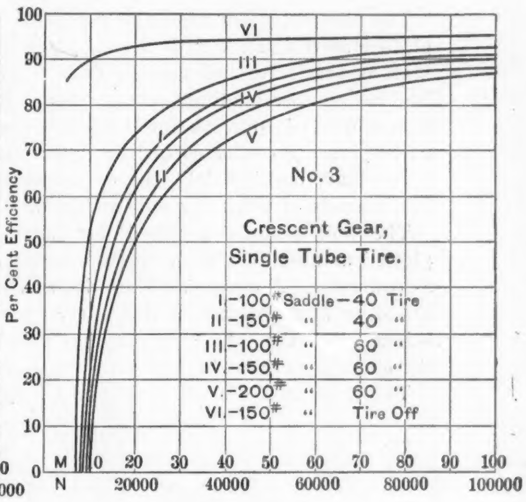
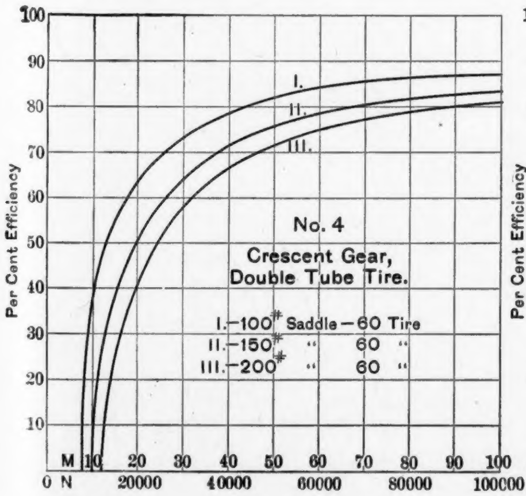
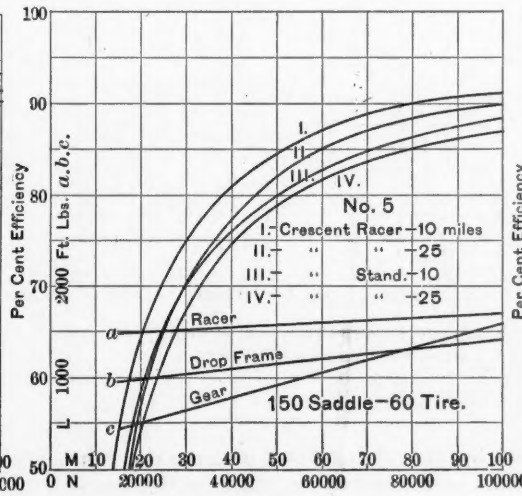


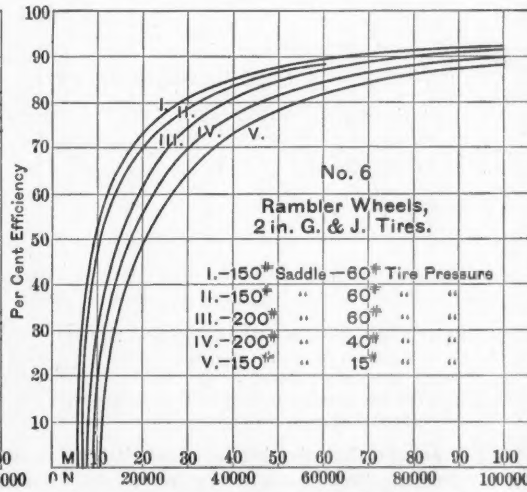
N.—Gross Work per Mile. Ft. Pounds.
Speed, 10 Miles per Hour.
M.—Equiv. Crank Pressure; 6½. in Crank; 71 in. Gear.



M.—Equiv. Crank Pressure; 6½ in. Crank; 71 in. Gear.
N.—Gross Work per Mile. Ft. Pounds.
Speed, 10 Miles per Hour.



L.—Lost Work Due Side Thrust on Frame per Mile.
M.—Equiv. Crank Pressure; 6½ in. Crank; 71 in. Gear.
N.—Gross Work per Mile. Ft. Pounds.



M.—Equiv. Crank Pressure; 6½ in. Crank; 71 Gear.
N.—Gross Work per Mile. Ft. Pounds.
Speed, 10 Miles per Hour.
I., III., IV., V.—New Wheel and Tire.
II.—Old Wheel, with same Tire as on New Wheel.

was found to change slightly with the load, but not at all with the speed.

The tachometer was calibrated so as to give the revolutions of the crank shaft per minute by running at various speeds, reading the tachometer and taking a record upon the electric speed register for each speed.

The dynamometer was calibrated by attaching a prony brake to the pulley shown at the right of the dynamometer, and comparing the readings of the brake scales with the dynamometer scales. It will be seen that this method of calibration eliminated the friction of the bearings between the dynamometer and bicycle.

It was early discovered in bicycle testing that very large changes in efficiency were produced by changes in tire pressure, and saddle load, and that different tires, even those of the same

In order to determine the effect upon the efficiency of propulsion of the alternating thrusts upon the crank shaft, due to the motion of pedaling, and which does not enter the above tests, runs were made with several of the bicycles with a weight of 80 pounds attached to the crank and revolving concentrically with the crank shaft. This substituted for a side thrust during alternate half revolutions, upon opposite crank shaft bearings, a continuous downward pressure on one, and upward pressure on the other bearing; a condition certainly as hard upon the bearings as the actual condition when riding. Cut B shows the apparatus arranged for this test.

Method Determining the Results of the Tests.

The results of the tests were obtained from the data in the following manner: For the tests with tire on the circumfer-

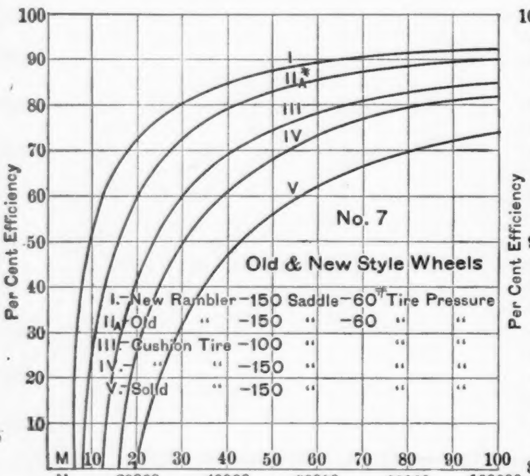
ence of the track wheel was measured, and from this the number of times the wheel would revolve in rolling one mile determined. Then the circumference of the circle of which the prony brake arm is a radius, multiplied by the revolutions of the track wheel per mile, gives a constant which, multiplied by any brake reading, gives the foot pounds of work delivered by the bicycle to the track wheel, per mile, for that particular brake reading.

Dividing the revolutions of the track wheel per mile by the ratio between the revolutions of track wheel, and revolutions of crank shaft, as found from the electric speed register, gives us the revolutions of crank shaft per mile for that ratio. This, multiplied by the foot pounds of work performed per revolution of the crank shaft, and per pound of dynamometer scale reading, as found from the dynamometer calibration, gives a constant, which multiplied by the dynamometer reading, becomes the foot pounds of work per mile received by the bicycle.

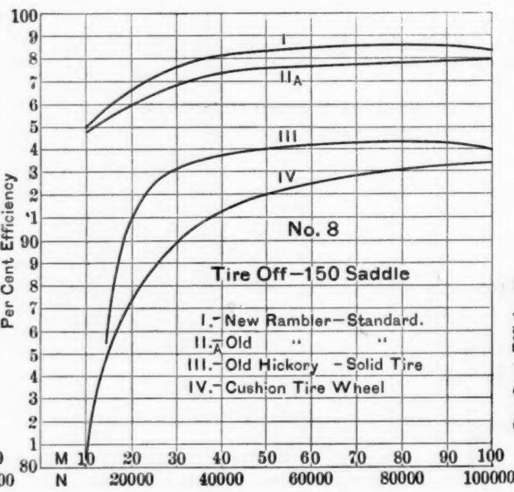
The dynamometer readings for each brake load were first plotted as ordinates, with the corresponding tachometer readings as abscissae, and a curve drawn connecting these points. The tachometer readings corresponding to the speeds at which it was desired to work up the test were determined, and the corresponding ordinates on the dynamometer curves, for each brake load, multiplied by the dynamometer constant, gave the foot pounds of work ~er mile received.

The foot pounds received for any one speed were then plotted as abscissae, with corresponding foot pounds delivered as ordinates. A curve was then drawn connecting these points. Dividing any ordinate of this curve by the corresponding abscissa gives the efficiency for that abscissa. In this manner the efficiency curves here given were obtained.

The tests with tire off were worked up in t.ie same manner,



M.—Equiv. Crank Pressure; 6½ in. Crank; 71 in. Gear.
N.—Gross Work per Mile. Ft. Pounds.
Speed, 10 Miles per Hour.
* II.A—Had been ridden 1100 miles and was tested with old patched tire.



M.—Equiv. Crank Pressure; 6½ in. Crank; 71 in. Gear.
N.—Gross Work per Mile. Ft. Pounds.

except that the brake constant was found by multiplying the revolutions of the dynamometer shaft per mile by the ratio of the bicycle gearing, to obtain the revolutions of the rear wheel, and then multiplying this by the circumference of the rear wheel at the bottom of the felloe, to obtain the feet traveled per mile by that part of the rear wheel to which the rope brake was attached.

Most of the tests were made for tire pressures of 60 and 40 pounds, and saddle loads of 100, 150 and 200 pounds. All the tests except those in which it was desired to obtain the effect of speed changes, were worked up for a speed of ten miles per hour, that being considered as representing the ordinary riding speed.

Maximum Power of a Bicycle Rider.

To obtain some idea of the maximum power developed by a bicycle rider, some tests were made with a bicycle mounted on the testing frame, but with the transmission dynamometer detached. An expert rider then took his place in the saddle, and propelled the bicycle at a speed of ten miles an hour.

The wheel was geared to 71.5, and had 6½-inch cranks.

The brake was adjusted to the maximum resistance the rider was capable of overcoming, and from the brake reading thus obtained, and the known efficiency of the bicycle, the foot pounds per mile put into the bicycle by the rider found. This was done with two different riders both stronger than the average, and the maximum found to be 40,000 foot pounds per mile. This corresponds to a continuous pedal pressure of 42 pounds, or at the speed of ten miles an hour, to .20 of a horse power.

In studying the efficiency curve, it is well to bear the above facts in mind, for, according to the results of this investigation, that portion of the curves lying beyond 40,000 foot pounds received are of no interest to the bicycle rider as such; although of great interest to the engineer as showing the law of increase of efficiency, with increase of power transmitted, through a range extending nearly to the maximum efficiency for the particular machine under consideration.

Description of Plates.

Plate No. 1 gives the efficiency for various amounts of work received per mile for each of the different types of Crescent wheels fitted with Dunlop double tires, with 60 pounds tire pressure and 150 pounds saddle load. The racer was provided with racing tires, the rest with road tires. The corresponding pedal pressures are also given.

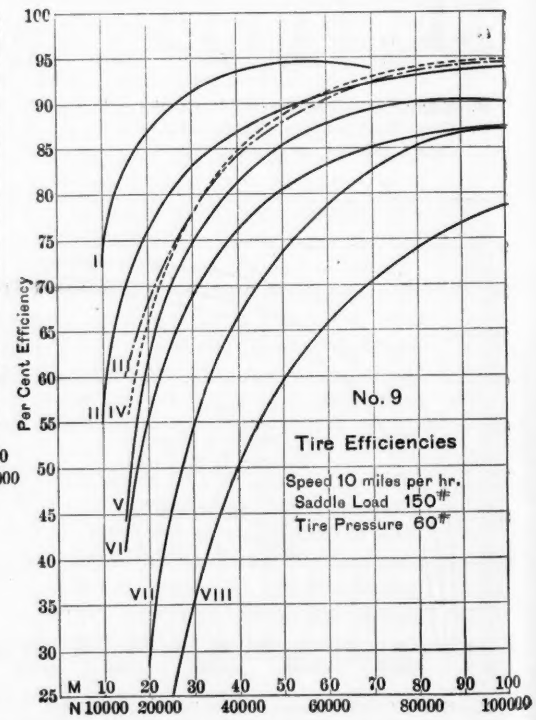
Plate No. 2 gives the efficiency of the gearing and bearings of the same wheels, the tires being removed.

Plate No. 3 shows the effect upon efficiency of changes of tire pressure and saddle load with Hartford single tube tires.

Plate No. 4 shows the same with Dunlop double tube tires.

Plate No. 5 has two sets of curves, one showing the change in efficiency due to change of speed, and the other the lost work due to the action of pedaling.

Plate No. 6 compares, in curves I. and II., a new Rambler



M.—Equiv. Crank Pressure; 6½ in. Crank; 71 in. Gear.
N.—Gross Work per Mile. Ft. Pounds.

No.	Name.	Kind.	Wt. Lbs.	Diam inch.
I.	Victor Special Racer	Single Tube	......	1½
II.	G. & J. Tandem.	Double "	2.70	2
III.	Dunlap Road Racer	" "	1.50	1⅛
*III.	Diamond	Single "	2.03	1⅝
IV.	Hartford	" "	1.94	1⅝
†V.	G. & J.	Double "	2.02	1⅝
VI.	Dunlap	" "	1.78	1⅝
VII.	Cushion	....	......	1¼
VIII.	Solid	....	2.42	13/16

* III.[1] Ridden 500 miles. Good shape.
† V. Ridden 1100 miles. Patched.

with one that has been ridden 1,600 miles, the same tire being used on both. The remaining curves of the plate show the changes due to changes of tire pressure and saddle load, with Rambler wheels fitted with G. & J. tandem 2-inch double tube tires.

Plate No. 7 compares the solid rubber, cushion and pneumatic tires, and curves III. and IV. show the effect of change of saddle load with the cushion tire.

Plate No. 8 shows the efficiency of gearing and bearings of

the Rambler compared with the "out of date" wheels which were provided with the solid and pneumatic tires. The wheel from which Curve III. was obtained was a "Hickory," provided with parallel bearings, but in excellent shape, while Curve IV. was obtained from a wheel, the name of which could not be found, provided with ball bearings, but in very poor condition.

Plate No. 9 gives the tire efficiencies alone for all the tires used in this series of tests, and in addition a Victor racing tire.

Conclusions.

First. From Plates 1 and 2 it is seen that the drop frame and standard do not vary more than 2 per cent in the riding limit, while the chainless lies several per cent below and the racer an equal amount above. However, the entire difference is no more than exists between tires of the same make and grade.

Second. Plate 5 shows that change of speed affects the light racing tire much more than it does the road tire. It also shows that the effect of the pedaling action was greatest with the light racing frame, and greater within the riding limits with the drop frame than with the standard frame, but very small in all three cases.

Third. The difference between the old Rambler and the new, as shown by Plate 7, is nothing more than might exist between two new wheels of the same make.

Fourth. While the pneumatic tire, as shown by these tests, is an inefficient power tr-nsmitting device, yet when compared, as in Plate 9, with the cushion and solid tires which preceded it, it is seen to mark the greatest advance yet made in bicycle construction.

CRESCENT CHAINLESS OR GEAR EFFECTS OF TIRE PRESSURE AND SADDLE LOAD.

Foot Pounds per Mile Expended.	Equivalent H. P.	Pedal Pressure. 6½ in. Crank. 71 Gear.	Efficiencies. Single Tube Tire. Tire 40 Sad. 100	T. 40 S. 150	T. 60 S. 100	T. 60 S. 150	T. 60 S. 200	Double Tube Tire. T. 60 S. 100	T. 60 S. 150	T. 60 S. 200
10 000	.05	10	32	10	50	21	......	38	12	......
20 000	.10	20	65	54	73	61	50	64	50	42
30 000	.15	30	76	68½	81	73	64	74	64	58½
40 000	.20	40	82	77	85	80	72	79	72	67
60 000	.30	60	88	84	89½	86	80½	83½	79	75
80 000	.40	80	90	87	92	88½	84½	85½	82	78½
100 000	.50	100	91	88½	93	90	87	87	84	81

SUMMARY OF RESULTS.

Foot Pounds per Mile Expended.	10 000	20 000	30 000	40 000	60 000	80 000	100 000	Saddle Load, lbs.	Tires. Name.	Diam. in.	Wt. lbs.	Pres.	Height of Frame.	Tread.	Wt. Wheel Stripped.
Equivalent HP	.05	.10	.15	.20	.30	.40	.50	....	....	....	....	....	....	....	....
Pedal Pressure lbs., 6½ in. Crank, 71 Gear	10	20	30	40	60	80	100	....	....	....	....	....	....	....	....
	Per cent. efficiency Tire on.							....	....	....	....	....	....	....	....
Crescent Road Racer	32	62	74	81	87	90	92	150	Dunlap	1½	1.50	60	24	4⅞	22½
" Drop Frame	20	55	69	76	84	88	90	"	"	1⅝	1.78	"	22		25½
" Standard	26	57	70	76	83	87	88	"	"	"	"	"	24	"	25
" Gear or Chainless	12	50	64	72	79	82	84	"	"	"	"	"	24½	"	27½
" " " "	21	61	73	80	86	89	90	"	Hartford	"	1.94	"	"	"	"
Rambler (new)	52	73	81	85	89	91	92	"	G. & J.	2	2.7	"	24	5	27
" (new)	....	49	64	73	82	86	88	"	"	"	"	15	"	"	"
" (new)	30	62	75	81	87	90	91	200	"	"	"	60	"	"	"
" No. II. (old)*	45	70	79	84	88	91	91½	150	"	"	"	"	"	"	"
" No. II.A (old)†	23	60	73	80	86	89	90	"	"	1⅝	2.02	60	22	"	25
Cushion Tire W.	....	26	50	61	73	80	82	"	Cushion	1½	....	....	22	....	50
Old Hickory	....	3	33	48	62	70	74	"	Solid	1 3/16	2.4	....	22	...	42
	Per cent. Efficiency, Tire off.							....	....	....	....	....	....	....	....
Crescent Racer	94	95	96	96	96	96	96	....	....	....	....	....	....	....	....
" Drop Frame	84	92	94	95	96	96½	97	....	....	....	....	....	....	....	....
" Standard	88	94	96	96½	97	97½	98	....	....	....	....	....	....	....	....
" Gear or Chainless	90	92	93½	94	94½	94½	95	....	....	....	....	....	....	....	....
Rambler (new)	95	96.6	97.6	98	98½	98½	98.5	....	....	....	....	....	....	....	....
" No. II.A (old)	94.8	96	97	97½	97.6	97.8	98	....	....	....	....	....	....	....	....
Old Hickory	....	91	93	93.8	94	94.4	94	....	....	....	....	....	....	....	....
Cushion Tire Wheel	....	87½	90	91.3	92.5	93.2	93.4	....	....	....	....	....	....	....	....

* No. II.—Had been ridden 1,600 miles, with same tire as on new wheel.
† No. II.A—Had been ridden 1,100 miles. Tested with old, patched tire.

Actual Efficiency of Propulsion.

As stated at the beginning of this article the laboratory tests do not include a measure of all sources of loss in the bicycle; however, the only losses omitted which are not negligible when compared with the total are the losses due to the front tire and the air resistance. To obtain some idea of the efficiency of the bicycle as a whole, these losses must be included, and to do this the following method of deduction was followed:

The grade and speed were first assumed, and the distribution of weight upon the two wheels determined. Then the weight upon each wheel into the distance that weight is elevated in traveling one mile, gives the net work to be done by that wheel in foot pounds per mile. From the efficiency of the tire the gross work necessary to accomplish the net work of the front wheel is found. The power to furnish this gross work, as well as to overcome the air resistance, must come from the rear wheel. Hence the total work deliverd by the rear wheel must be the sum of the foot pounds delivered to the front wheel, the foot pounds necessary to overcome the air resistance, and the foot pounds used in elevating its own share of the load. From the tire efficiency the foot pounds which it is necessary to deliver to the rear wheel to accomplish this is found, and then, from the known efficiency of the bicycle gearing, and bearings, the foot pounds per mile received by the bicycle can be determined.

The external resistances to be overcome by the bicycle are the air resistance, and the elevation of rider and bicycle through the given distance. Dividing the external resistances reduced to foot pounds per mile, by the foot pounds per mile delivered to the bicycle, gives the actual efficiency of propulsion.

This was worked out for the Crescent Standard wheel, and Hartford road tire, with results as follows:

Speed, 10 miles per hour.

Air resistance 6,900 foot pounds per mile (from Sharp's "Bicycles and Tricycles.")

Grade per cent.	Ft. lbs. per mile received.	H. P.	Efficiency.
0	17,300	.09	40
0.5	22,200	.11	52
1	26,800	.14	60
2	36,400	.18	70
3	45,700	.23	76
4	55,500	.28	79

* * *

THE NIAGARA FALLS CONVENTION.

The Niagara Falls Convention of the American Society of Mechanical Engineers occurred May 31 to June 3, with headquarters at the Cataract House, where the professional sessions were held. As a matter of course the Summer meetings, especially when held at a place like Niagara Falls, are quite as much of an event socially as they are professionally. Socially this meeting was in every respect a marked success. Professionally it did not, perhaps, score quite as high. The technical papers as a whole were not as interesting as usual, although a number of them met with quite general approval, and were recognized as of great value to the practitioner. Instead of attempting to summarize all of the papers, some of which would not be of interest to the readers of this paper, we shall publish abstracts more or less complete of several of them,

The opening session Tuesday evening was occupied by an address of welcome by Hon. Arthur Hastings, Mayor of Niagara Falls, and by a talk by Mr. Coleman Sellers, of Philadelphia, consulting engineer of the Cataract Construction Co., upon the mechanical features of the plant of this company. The lecture was illustrated by stereoptican. At the Wednesday morning session the first papers were presented and various reports were read. It was stated by the secretary that the present membership is 1,887.

The chief social events were the reception and supper Wednesday evening at the International Hotel, and the excursion down the gorge Thursday afternoon. This included a trip on the Canadian side from Chippewa to Queenstown, across the river to Lewistown and Fort Niagara; and return on the American side through the gorge.

Much interest was also shown in the visits to the plants of the Niagara Power Company and the Niagara Falls Hydraulic Power & Manufacturing Company, and also to the works of the Carborundum Company. The total attendance of members and friends was 345.

* * *

What is said by "The Engineer" to be the fastest steam yacht in the world is the "Ellide," designed by C. D. Mosher, of New York, and owned by E. B. Warren, of Philadelphia. It is claimed to have developed a speed of 40 miles per hour.

PLANOID AND OCTOID TEETH.

Mr. George B. Grant has furnished us with additional information about his bevel gear cutting machine, described in the last issue, which we did not secure in time for use in that number. It will be remembered that it was stated that this machine cuts a planoid tooth instead of the octoid tooth, which was originated by Bilgram, and is cut by his machine. In Grant's machine the blank rolls as if its pitch cone was rolling on the pitch cone of the gear with which it is intended to work. This is accomplished by rotating the gear, and at the same time swiveling the carriage about a vertical axis directly under the apex of the pitch cone of the gear being cut.

The cutter is flat and radial, while in cutting an octoid tooth a cutter which is not radial would be used. The cutter represents and is in the position of the flank of the tooth of the only spur gear with which the gear being cut will work. In cutting the octoid tooth on the Bilgram machine the cutter represents and is in the position of the whole tooth face of a crown gear. The Grant gears are not interchangeable and each one must work with a gear of a definite size and center angle. This can be no objection, however, since where bevel gears are interchangeable, whenever the mating gear is changed the shaft angles also change, thus destroying the only advantage of interchangeability.

The planoid tooth gradually approximates to the true epicycloidal as the shaft angle approaches zero, from the spur gear. The octoid curve approaches the true involute as the bevel gears approximate to spur gears. The two systems for bevel gears are equivalent respectively to the epicycloidal and the involute systems for good spur gears. The differences are theoretical only and are too small for practical importance.

* * *

ABOUT A FOLLOWER BOLT.

Not long ago one of the engines broke down that had been erected at a Southern cotton mill by the Great Western Engine Works. I call them the "Great Western" works because they are situated in the Western Hemisphere, and that is as close as I care to come to it in print, not being very proud of the incident.

The trouble was with a piston follower bolt, or rather bolt head, for the head of the bolt pulled off, cracked the cylinder head and bent the piston rod about an inch out of line. This happened in the high pressure cylinder. Nobody was hurt, but it cost $250 to make everything right again, and all that saved shutting down the mill for two weeks was the fact that the low pressure cylinder was connected up with direct piping and a reducing valve, so that high pressure steam could be used in it.

Immediate investigation followed the break and it was found that the bolt had been made of machine steel, with the head welded on. The weld did not hold and the head slipped off. Further investigation showed that the drawing called for machine steel bolts for holding the piston follower in place, so that it could not be said that the work had been done contrary to drawing. On the other hand, if the bolts had been made from bar steel, without welding, the accident would probably not have happened. Also, if they had been made of Norway iron, contrary to drawing, and either welded or solid, the accident would doubtless not have happened. You can weld iron and make it stay where you can't weld steel, and that is a point that ought to have been looked out for, but wasn't. It appeared that the general foreman, who was an old engine hand, had ordered the bolts with no special instructions, and that they had been welded, according to custom; but in this case custom had proved to be an expensive teacher—much more so than individual judgment would have been.

It is not usually very profitable to spend much time trying to find who is responsible for this or that blunder, and in this case, especially, there would be a wide diversity of opinion. This little incident, however, shows three facts that are worth repeating. First, that to be an A No. 1 draughtsman a man ought to have had enough shop experience and acquaintance with the actual working of materials to enable him to look out for practical constructive points such as above recited. There are too many draughtsmen who have been brought up in the drawing room instead of the shop, and who are not even good observers of shop methods.

The second fact is that a drawing to be A No. 1 should contain explicit directions as to what is and what is not wanted. If this drawing had read "Follower Bolts of Norway Iron from the Solid Bar," there would have been no mistake. Some draughtsmen don't like to letter, anyhow.

The third fact is that foresight is a much more valuable characteristic for a fireman to cultivate than hindsight, which doesn't need any cultivating. Had the foreman done a little hard thinking about the details of his forgings he might have prevented the break. In nine cases out of ten, however, a foreman has to spend more time on cost reduction than in seeing that his work is done properly and so it will stand. Would it not pay to let him put in a little time in studying results and consequences? At least, I purpose to devote a little time to that end of it, whether they want me to or no, as personally, I believe a slice of that $250 accident falls on my shoulders.

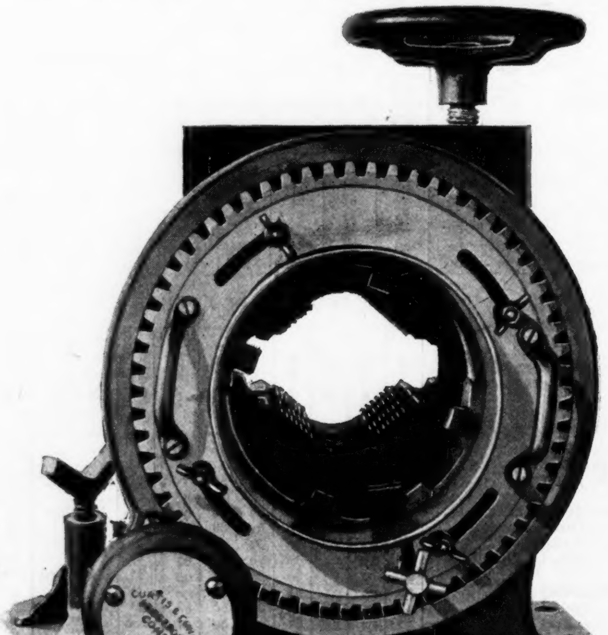
THE GENERAL FOREMAN.

* * *

A LARGE PIPE THREADING MACHINE.

Messrs. Curtis & Curtis, of Bridgeport, Conn., have recently placed on the market a new design of their Forbes patent die stock, which is probably the largest hand die stock ever built. It cuts off and threads all sizes of wrought iron pipe from 2½ to 10 inches right hand, and it is stated that even 10-inch pipe can be cut off and threaded by a strong boy.

The pipe is inserted from the back of the machine and is clamped by the self-centering vise attached to the machine. As the large die carrying gear is revolved in the shell by a small pinion embedded in the side of the shell, it is drawn toward the end of the pipe by a lead screw on its back and the dies are thus fed to the pipe. When the required length of thread is obtained



A LARGE HAND DIE STOCK.

the dies are thrown back and the pipe taken out, without running back over the thread. Only three sets of dies are used for the full range of the machine, and they are all made opening and adjustable to any variations of the fittings. The machine is also arranged to cut off all sizes of pipe within its range.

Experience has shown that it is much more economical to use a portable pipe machine which can be carried from place to place and the work done on the spot, than to try to cut the pipe to measurements at a distance. For not only is there much less chance of mistakes, but much time, delay and carting is saved.

This machine is also fitted when desired with a power base and countershaft. It can then be used either as a power machine in the shop, or taken from its base and carried out on a job as a hand machine.

THE HEATING SURFACE OF A STEAM BOILER.*

WHY THE FIRE SIDE AND NOT THE WATER SIDE IS THE MEASURE OF THIS SURFACE.

It is a remarkable fact that in computing boiler heating surface, an error of from 7 to 17 per cent. is made by a large proportion of steam engineers and boiler manufacturers. The error consists in taking the surface in contact with the water, instead of that exposed to the fire or hot gases, as the heating surface. If the heating surface is flat, of course the areas are the same; but the boiler heating surface is in most cases made up of tubes, and the difference between the interior and exterior surface of a boiler tube is as much as 17 per cent. of the interior surface in the case of a 1-inch tube and is about 7 per cent. in a 4-inch tube.

The error arises in the first place from a failure to appreciate the fact that the heating surface exposed to the fire is the actual heating surface of the boiler, on which its capacity depends. A clear understanding of this fact is so important, and it has been and is so generally mistaken by engineers and writers of engineering works, that the writer ventures to submit a discussion of the elementary principles on which this assertion is based.

Suppose we have an iron plate 1 inch thick, on one side of which is flowing a current of hot gas at a temperature of, let us say, 1,000 degrees, and on the other side is a body of water in a steam boiler at a temperature of 300 degrees (corresponding to a gauge pressure of steam of about 52 pounds).

Now the heat in passing from the hot gas on the side of the plate to the water on the other meets with three different resistances as follows:

(1) Resistance in passing from the gas to the surface of the plate.

(2) Resistance due to the passage through the plate.

(3) Resistance due to the passage from the other surface of the plate to the water.

The heat conductivity of metals has been carefully determined by experiment in physical laboratories, so that if we know the actual temperatures of the two surfaces of a plate and its thickness, we can at once determine how much heat is passing through a unit area in a given time. On the other hand, if we know how much heat is passing through the plate, we can determine what is the difference of temperature of its two surfaces. Let us solve an example of the latter sort: Suppose the plate is transmitting heat enough to evaporate 3 pounds of water per hour from and at 212 degrees per square foot of its area, or about the average rate that the heating surface transmits heat in an ordinary stationary boiler. Since 965.7 heat units are required to transform a pound of water at 212 degrees into steam at the same temperature, the plate will transmit $3 \times 965.7 = 2{,}897.1$ heat units per square foot per hour, or for convenience let us say 2,000 heat units.

Now experiments on the conductivity of metals have shown that an iron plate 1 foot square and 1 inch thick whose opposite surfaces are kept at a uniform difference in temperature of 1 degree Fahr. will transmit in an hour 473 British thermal units. Hence to transmit 2,000 British thermal units per hour, the difference in temperature of the two sides of the plate will be $2{,}900 \div 473 = 6.13$ degrees.

I doubt not it will surprise many to learn that so small a difference of temperature between the two surfaces of an iron plate is sufficient to cause so large an amount of heat to flow through it; but the coefficient for the heat conductivity of iron on which it is based is the result of many experiments by the most eminent physicists, and is accepted as correct by the best scientific authorities, and there is no reason to doubt its accuracy.

In studying our present problem, however, the exact accuracy of the coefficient is a matter of no particular importance. We just found that boiler heating surface 1 inch thick, when transmitting 2,900 heat units per hour, will have a difference of temperature on its two sides of 6.13 degrees Fahr. But we never have heating surface of such thickness in steam boilers. The shell heating surface in internally fired boilers is seldom over 5/8-inch thick. Furnaces and fire boxes are made of 1/4-inch to 3/8-inch plates, while tube heating surface is from 1-16 to 1/8-inch thick. We see then that the actual difference of temperature between the two surfaces of a boiler tube transmitting heat at the rate already named will be from 1/8 to 1-16 of 6.13 degrees, or in round numbers from 3/4 degrees to less than 1 degree Fahr. As the eminent physicist Lord Kelvin has said, for all practical purposes, we may consider that the heating surfaces of steam boilers conduct heat as if they were no thicker than paper, or as if the metal were of infinite conductivity. It will be seen also that an error of 50 per cent., or even of several hundred per cent., in determining the coefficient of conductivity of iron, even if such an error were probable, would make no practical difference in this conclusion.

There are many facts of practical importance to be drawn from this. For example, in its light we can readily see how little reason there is to expect any greater economy in locomotive boilers with brass or copper tubes and fire boxes than in those of steel. Yet we still hear the superior conductivity of copper urged as a reason why English railways stick to the use of copper fire boxes.

Turning again to the plate, we know now that the two surfaces (if we conceive its thickness reduced to that of an ordinary boiler tube), will have only a trifling difference of temperature. Next let us discuss the relative heat-absorbing powers of the water on the one side of the plate and the hot gases on the other. It is to be kept clearly in mind that the temperatures of the two sides of the plate which we have just considered are the temperatures of the skin of the plate itself, which is quite a different matter from the temperature of the air or the water in contact with the plate.

If this is clearly understood, it will be easy to understand that the actual temperature of the plate itself depends on the relative heat-transmitting power of the fluids on its two sides. If these fluids were the same on the two sides, and were at the same temperature and under the same conditions as respects mobility, then the plate temperature would be a mean of the temperatures of the fluids on its two sides. But in the case shown in Fig. 1, since water is many times as efficient as air or furnace gases in absorbing heat, the plate temperature will be nearly the same as that of the water and far below the temperature of the hot gases.

This is a fact which is a matter of common knowledge; and yet it has been overlooked by many engineers and by engineering writers; and because it has been overlooked is one main reason why engineers have not always insisted on the fire side of tubes being considered the heating surface of steam boilers.

Let us review some of the facts which show the relative heat-absorbing power of water and gases: Take an iron rod and heat it to redness, then let it be held still with only the air in contact with it, and see how long a time elapses before it is cool enough to be touched. Heat the rod to redness again and then plunge it in water, and again note the time before it can be touched. We have then a very rough approximation of the relative heat-absorbing powers of air and water.

Again, experiments have been conducted to determine the temperature to which a metal plate could be heated when one side was in contact with water. The temperature was determined by inserting in it plugs of various fusible alloys, and the fire side of the plate was then subjected to the most intense heat that a powerful blow-pipe could produce. So long as the water side of the plate was clean, it was impossible to melt the fusible plugs.

The most striking illustration, however, which the writer has ever seen of the large heat-absorbing power of water, as compared with air, was an experiment conducted by him for another purpose some years ago. A vessel having a single vertical tube of about 2 inches diameter was filled with cold water (45 degrees to 50 degrees Fahr.); the hot gases from a large oil lamp or a Bunsen burner at a temperature of some 1,000 degrees or more were then passed up through the tube. The surface of the tube exposed to the hot gases was kept so cold by the water on the other side that drops of dew were condensed upon it from the hot gases, and the interior of the tube became actually coated with dew, which remained until the water was warmed to about 60 degrees. I advise anyone who may not be convinced as to the enormous heat-absorbing power of water as compared with gases, to try this simple experiment.

* From a paper read before the American Society of Mechanical Engineers, by Charles W. Baker.

It is very easy to understand why water should have so much greater heat-absorbing power than air. The specific heats of water and air are as 1 to 0.23 for equal weights; but since air at ordinary temperatures weighs only 1-812 as much as an equal volume of water, if we consider a thin film of air in contact with a hot surface and a film of water of equal thickness and area in contact with a similar hot surface, the water would absorb 3,530 times as much heat as the air if the tempertures of each were raised an equal amount. Again, the relative heat conductivities of water and of air, according to Lord Kelvin, are as 40 to 1. On the other hand, in the transmission of heat from a surface to a fluid, the mobility among the particles of the fluid, whereby fresh portions of it are constantly brought in contact with the surface, is a matter of great importance, and in this respect air, of course, has a considerable advantage.

The writer has been unable to find any trustworthy figures for the relative heat-absorbing power of air and water; and the practical importance of their accurate determination would be trifling, for we know in a general way and from the examples already cited that water absorbs heat very many times more rapidly than air, so many times that in the case of a thin metal plate, such as a boiler tube, transmitting heat from furnace gases on the one side to water on the other, we can be quite certain that the temperature of the metal plate is at most only a few degrees warmer than the water in contact with it.

If, now, it is clear that the fire side of the boiler tube or flue is at practically the same temperature as that of the water in the boiler, the reader will have little difficulty in comprehending that this surface, and not the surface on the water side, is the real heating surface of the boiler, which measures its capacity of making steam.

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NEW TOOLS.

A new wrench operating by a cam lever has been brought out by the Billings & Spencer Co., Hartford, Conn., intended for small finished work where there is danger of marring the corners and

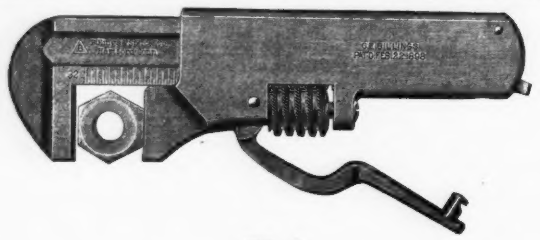


FIG. 1.

edges. Fig. 1 shows the wrench with the cam lever open ready to engage the nut or other piece to be grasped. The sliding jaw is screwed up in the usual manner until it nearly grasps

FIG. 2.

the nut; then the cam lever is pressed toward the handle until the sliding jaw grips the nut, as in Fig. 2, holding it firmly and giving no chance for lost motion that would injure the corners of the nut. The lever is released by pressing down the catch at the end of the handle. The wrench weighs 8 ounces.

Another new Billings & Spencer tool is the depth gauge, which is shown in half size in Fig. 3. The long screw works in a half nut, and by making one-half turn of the thumb-screw and pressing on the same the threaded rod is released from the half nut and can be moved freely up and down, releasing the pressure. The half nut is locked with the screw by action of a spring inside of the nut. Fine adjustment can then be made by turning the screw, and when the rod is set right it can be kept from moving by turning the thumb-screw.

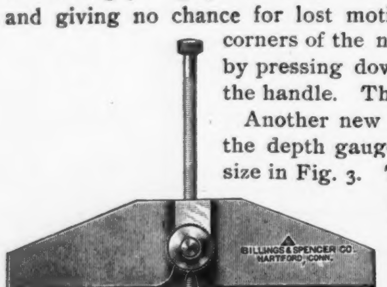


FIG. 3.

TESTS ON COVERINGS FOR STEAM PIPES.*

The apparatus for making these tests comprises several pieces of steam pipe of different diameters and lengths, heated electrically from within by means of coils of wire in oil. The oil is stirred vigorously and serves as a very efficient carrier of heat from the wires to the pipes.

In making a test the following operations are carried out, and observations are taken in the following order:

The current is turned on, and heat is generated in the wire coil until the wire, oil and steam pipe have reached the desired temperature at which it is proposed to test. The current is then gradually dimished until it is found to be of just the amount necessary to keep the pipe at this temperature without a rise or fall of $\frac{1}{10}$ of a degree in 30 minutes. A reading of the voltage and current is now taken at intervals of 30 seconds, and the watts and B. T. U. are computed from their average. We then have the number of B. T. U. lost from the outside of this particular pipe at this particular temperature. If now we place a steam pipe cover around the pipe, we shall find that a less amount of energy is sufficient to keep it at the required temperature, the difference being the amount of heat saved by the covering. It seems to me that I have approached more nearly the conditions of actual practice that can be obtained by any other method of testing, except the actual use of a long run of pipe; and the determination of the amount of heat put into such a pipe by the "condensation" method offers many difficulties and is open to much uncertainty. I feel, therefore, that in adopting this method I am using a reasonable exposure for the pipe, and have an exceptionally good opportunity to measure the heat supplied.

The money saving is computed on the following assumptions. Coal at $4 a ton evaporates ten pounds of water per pound of coal. The pipes are kept hot ten hours a day three hundred and ten days a year. If computations are made, as is sometimes done, on an assumption that the pipes are hot twenty-four hours a day three hundred and sixty-five days in a year, the saving is nearly three times that shown in the table.

Generally speaking a cover saves heat enough to pay for itself in a little less than a year, at 310 ten-hour days, and in about four months at 365 twenty-four-hour days.

Specimen.	Name.	B. T. U. loss per sq. ft. pipe surface per minute.	Ratio of loss to loss from bare pipe.	Thickness in inches.	Saving per year per 100 sq.ft.
A	Nonpareil Cork Standard	2.20	15.9	1.00	$37.80
B	Nonpareil Cork Octagonal	2.38	17.2	.80	37.20
C	Manville High Pressure	2.38	17.2	1.25	37.20
D	Magnesia	2.45	17.7	1.12	36.90
E	Imperial Asbestos	2.49	18.0	1.12	36.80
F	W. B.	2.62	18.9	1.12	36.40
G	Asbestos Air Cell	2.77	20.0	1.12	36.00
H	Manville Infusorial Earth	2.80	20.2	1.50	35.85
I	Manville Low Pressure	2.87	20.7	1.25	35.65
J	Manville Magnesia Asbestos	2.88	20.8	1.50	35.60
K	Magnabestos	2.91	21.0	1.12	35.50
L	Molded Sectional	3.00	21.7	1.12	35.20
M	Marsden Infusorial Earth	3.11	22.5	1.00	34.85
N	Marsden Infusorial Earth	3.27	23.7	1.00	34.60
O	Asbestos Fire Board	3.33	24.1	1.12	34.20
P	Calcite	3.61	26.1	1.12	33.24
	Bare Pipe	13.84	100	....	......

* From a paper read before the American Society of Mechanical Engineers, by Chas. L. Norton.

AMONG THE SHOPS.

MORE NOTES FROM CANADA, NORTHERN NEW YORK AND FURTHER WEST.

On entering a small Canadian machine shop my attention was attracted by the milling machine from which the enclosed photograph was made.

It has two graduated swivels, B and C, both operative in the same direction, and I failed to see why B was put there, for the swivel at C seems to answer every purpose, while the one at B does not appear to have any use whatever.

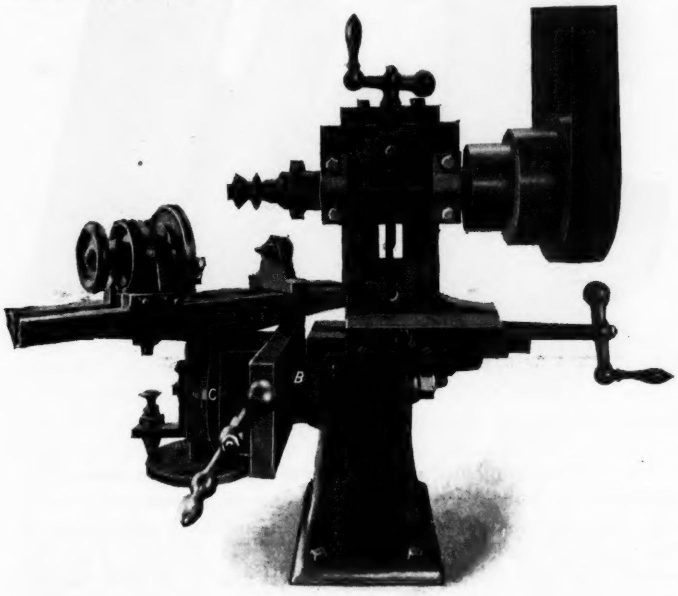


FIG. 1. ILLUSTRATING A BLUNDER.

The proprietors of two different shops where I found machines like this attempted to show me that the swivel at B was necessary in fluting taper reamers, etc., and in doing so convinced themselves that it made no difference whatever in the taper of the work whether B was set level or at an angle.

The graduations are the only things about its construction to indicate that it was intended to be used frequently, and since those who have owned and used them apparently for years without finding a use for the swivel, or even thinking of it, the natural conclusion is that it was a blunder in design, and C was added afterward to serve the purpose that B was intended to.

AT E. & B. HOLMES MACHINERY CO.'S.

In a previous issue of this paper, "A Roving Contributor" backed up his claim that a shifting belt was the nearest approach to a perfect friction clutch, with some very good arguments, and

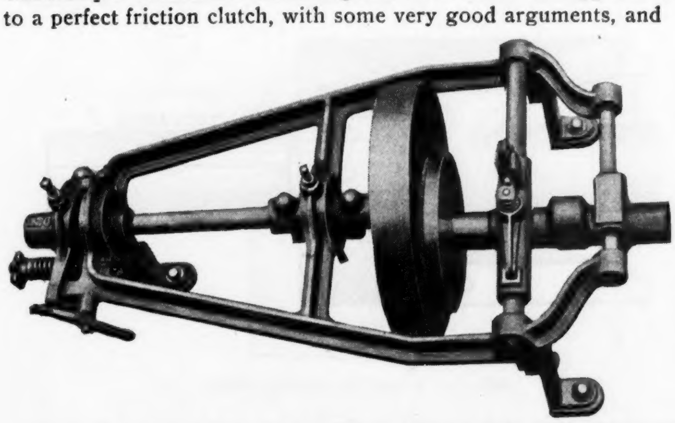


FIG. 2. THE HOLMES FRICTION COUNTERSHAFT.

the E. & B. Holmes Machinery Co., of Buffalo, N. Y., think the invention of Mr. B. Holmes, the essentials of which are illustrated herewith, is the nearest approach to an ideal system of frictional gearing for variable speeds.

The ultimatum, so to speak, of every mechanical problem is, consider the circumstances or suffer the consequences, and it cannot be expected that a shifting belt or the Holmes friction gearing can be used in every case where a friction clutch or variable speed is desired; but I would like to call attention to this device, which does not seem to be so well known as it should be, when there are so many cases where it could be used to advantage.

Briefly stated, the Holmes system consists of a wood faced disc, brought against a cast iron disc, from which it is driven by friction—there is no reason why other materials could not be used if desired. The driven disc is slightly inclined so that only one edge touches the face of the driver, and as the point of contact is moved to or from the center of the driver a slower or faster speed is obtained, a reverse motion resulting when it is moved across to the opposite side of the center of the driver.

In the form of a counter shaft it is manufactured for general use and extensive application. Two of them are being made at present for transmitting to 40 horse-power each. This system can be seen in use for various purposes in the Holmes works, where it has stood the test in a satisfactory manner, but space does not permit me to say more on this subject and I need not describe the automatic speed indicators, or the peculiar construction of the self-oiling ball bearing used.

Mr. E. F. Bengle, who superintends the work, has been a practical mill man himself, and the broad triangular base on the Holmes "buzz planes," which gives them the proper support on three points and provides convenient room for the operator's feet, is the result of his early experience, and is characteristic of the attention given to convenience and design that is pleasing.

Fig. 3 is my "Pony Premo's" description of a milling machine fixture. It is not the most valuable kink observed at the Holmes Machinery Co., but it is a departure in screw cutting that is amusing, and costs but a trifle. The nut for the lead screw F was made by babbitting it in position, and a square recess in the chuck piece H to receive the head of the screw to be milled makes it an easy matter to cut the quadruple thread of one inch pitch. The work fits closely in a hole through K for a guide,

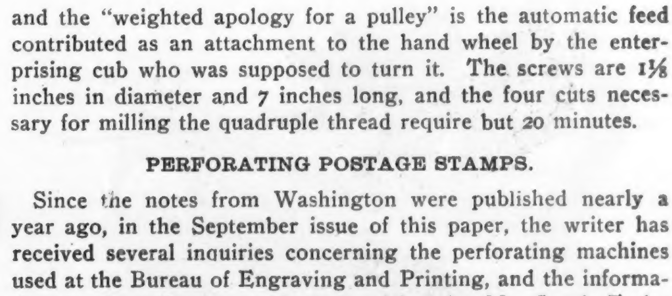


FIG. 3. MILLING A THREAD.

and the "weighted apology for a pulley" is the automatic feed contributed as an attachment to the hand wheel by the enterprising cub who was supposed to turn it. The screws are 1⅛ inches in diameter and 7 inches long, and the four cuts necessary for milling the quadruple thread require but 20 minutes.

PERFORATING POSTAGE STAMPS.

Since the notes from Washington were published nearly a year ago, in the September issue of this paper, the writer has received several inquiries concerning the perforating machines used at the Bureau of Engraving and Printing, and the information in the following reply is furnished by Mr. Jacob Emig, Superintendent of the Keystone Manufacturing Company of Buffalo, N. Y.

Seven of the machines in use at the Bureau of Engraving and Printing were built by this company, in addition to those turned out for other parties and those we are engaged on at the present time.

The gummed paper used for postage stamps cuts easily and the brass die rolls do a surprising amount of work in a satisfactory manner, but good steel or case hardened rolls are superior for some kinds of stock. We have made steel rolls 3" in diameter for perforating tissue paper and they worked all right. They were hardened by plunging them through about 4 inches of oil into a barrel of water and were used without having the temper drawn. For larger sizes case hardened rolls are used.

The punches enter the rolls no farther than necessary to cut

the paper properly. It is true that the punch rolls runs perfectly free on its shaft and no key is used to drive it, but the two shafts are connected by gears and driven at the same speed, the same as if keys were used, so that the lower roll does not have to overcome any friction whatever in driving it.

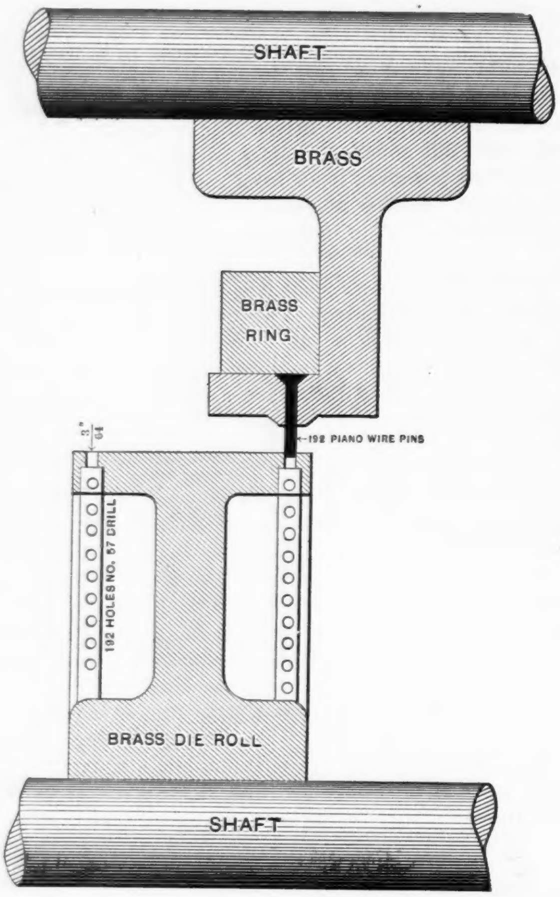


FIG. 4. POSTAGE STAMP PERFORATOR.

The sketch herewith is hastily made from rolls like those used on the postage stamp work, but shows the essential details more correctly than was possible in the September article by sketches made from memory from a brief observation of the machines in motion.

The drilling of the die rolls having two rows of 192 holes each was done at the rate of 22 rolls per day of 10 hours = 8,448 holes.

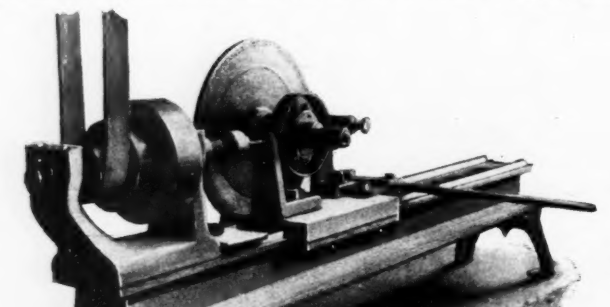


FIG. 5. DRILLING THE DIE ROLLS.

Fig. 5 is from a photo of the rig used. The whole fixture is moved by the lever which is locked to the ways of the lathe. An index plate of extreme accuracy is provided and the drill is guided by a bushing close to the work. No. 57 drill was used and the thickness drilled was about 3-64 of an inch.

SOME HEAVY CHIPS.

The chips shown in the photograph herewith were made in finishing the bed plates of an engine on a large Sellers planer at the Snow Steam Pump Works, Buffalo, N. Y., and the tool removed a strip of cast iron six inches wide by about 1-32 of an inch deep in making them, peeling off more than a pound and a quarter of metal in a single piece.

The photograph includes one of Coffin & Leighton's six inch scales which the maker presented to the writer as a souvenir of his visit to their works in Syracuse, N. Y., and will no doubt make the illustration more comprehensive to most mechanics.

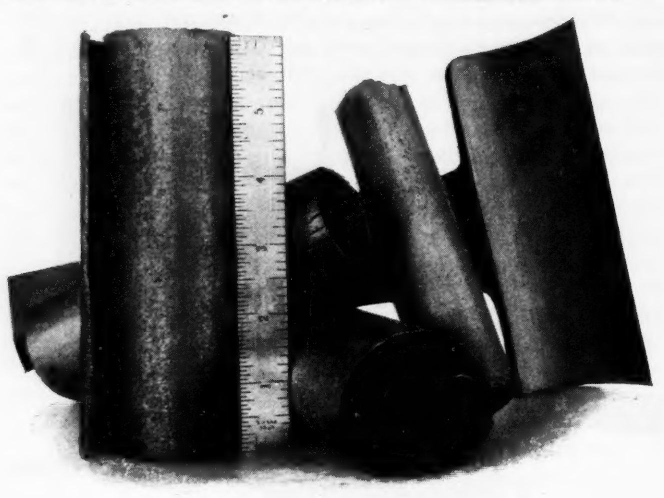


FIG. 6. A POUND AND A QUARTER A PIECE.

I appreciate good stiff machine tools, but the cases where it is necessary to leave a great mass of metal to be removed are so rare that they seldom occur where the conditions and nature of the work permit it to be cut away in great chunks. For that reason big chip stories never had a great deal of interest for me, but the quality of the iron indicated by these is quite as interesting as the chips themselves. I regret that I did not see them made, but assure the reader that there is no "fake" about them.

TOOLS FOR BORING LARGE HOLES.

Continuing west a machine having two vertical spindles with lateral adjustment sufficient to bore through both ends of a connecting rod simultaneously was seen in the Brooks Locomotive Works, at Dunkirk, N. Y. After putting a good sized drill through each end, two tools, as shown in Fig. 7, were used to complete the roughing operation. They removed the stock represented by the space between the bushing and cutters, and required an average of about one hour on rod ends 4 inches thick. The bushing can be renewed when desired, and it will be observed that the width of chip is divided between the two cutters, one cutting on the inside and the other on the outside edge. The same tools are also used for finish-

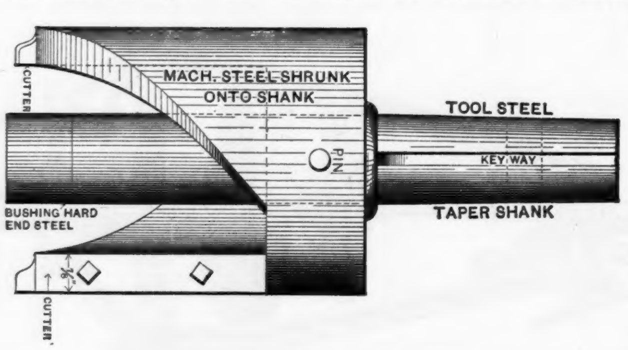


FIG. 7. A LARGE BORING TOOL.

ing the outside of hubs, and as the largest size makes a hole 8½ inches in diameter they would be considered large tools in a goodly number of shops. They are large enough for the work and are giving satisfaction, but in the matter of size they are eclipsed by Fig. 8, which is a similar tool found in the machine shop of the Cleveland City Forge Company, of Cleveland, O. When I saw this tool it was cutting a hole about 10 inches in diameter through a forging 9¼ inches thick, and removing the core in one solid block, which the operator said required about six hours. These forgings were such as are used in making built-up crank shafts, and had a hole in each end; and the size limits of the tool, so far as previous record

is concerned, was stated as equivalent to a hole 30 inches in diameter and 20 inches deep. The blades were made from good tool steel about 4 inches wide and ⅞ inch thick, with the cutting points upset to about 1⅛ inches. The straight, steady working of this tool proved that the tendency of the cutting points to "dig in," or crowd sidewise, was effectually overcome by locating the cutting edge a little back of the center

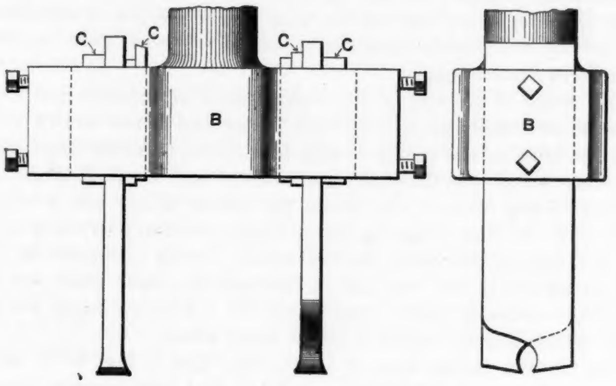


FIG. 8. A DOUBLE CUTTER HEAD.

of the block, and by proper grinding the tool was used on a powerful machine, whose name plate shows that it was built by Frede-ick B. Miles. The cutter head, B, is slotted on each side, and the blades are blocked out to suit the various sizes by parallel pieces, C. Much of the work done by this company is of a very heavy nature.

THE BALL QUESTION.

Prof. Benjamin's article in the March issue, describing the process of making steel balls at the Cleveland Machine Screw Company, does not leave much to tempt one to make them for his own use in small quantities.

Two methods of accomplishing the odd jobs of ball turning that are necessary have been described by "E. H. T." and Mr. Dunlap, but the ball subject is not yet exhausted, for these last two methods are too costly for manufacturing purposes, and it is extremely doubtful if the steel ball process is suitable for brass balls, billiard balls, etc., into which the grinding material would undoubtedly become imbedded by the rolling motion.

The Jarecki Manufacturing Company, of Erie, Pa., have machines made for this class of work, the elements of which are shown in the sketch made from memory (Fig. 9).

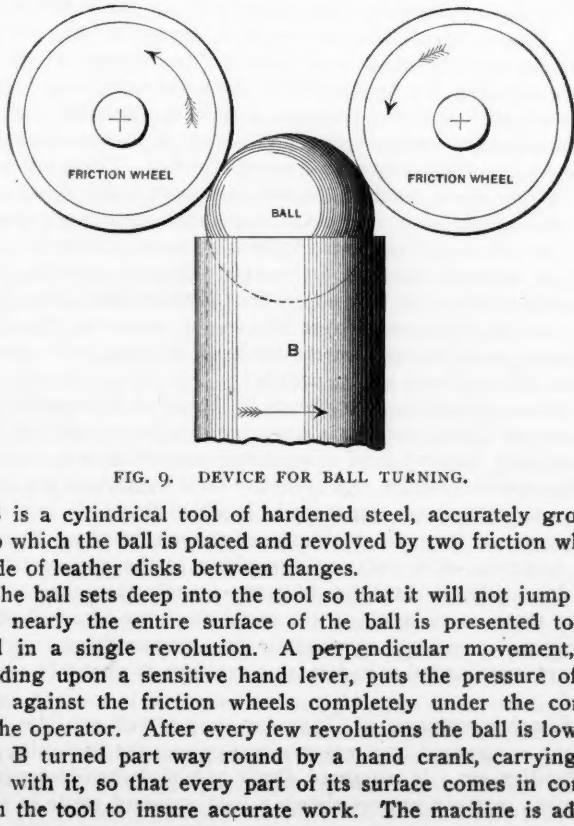


FIG. 9. DEVICE FOR BALL TURNING.

B is a cylindrical tool of hardened steel, accurately ground, into which the ball is placed and revolved by two friction wheels made of leather disks between flanges.

The ball sets deep into the tool so that it will not jump out, and nearly the entire surface of the ball is presented to the tool in a single revolution. A perpendicular movement, depending upon a sensitive hand lever, puts the pressure of the ball against the friction wheels completely under the control of the operator. After every few revolutions the ball is lowered and B turned part way round by a hand crank, carrying the ball with it, so that every part of its surface comes in contact with the tool to insure accurate work. The machine is adjustable to a wide range of sizes, and a machine on the same plan, having a hollow brass lap instead of a scraping tool at B, and soft rubber friction rolls is used for finishing with oil and emery or other polishing material.

Half the ball subject has never yet been told. Why not keep it rolling?

The Jarecki Manufacturing Company are extensive manufacturers of pipe connections, and some of the automatic machines used in this kind of work are remarkable examples of the extent to which the turret machine principle has been carried. I was informed that one of these machines had the capacity for threading 15-inch or 16-inch pipe connections. From the pit in which it stands it extends probably 10 or 12 feet above the floor. It was evidently turning out about 200 finished connections for 6-inch pipe per day when I saw it, and I regret that an illustration of the machine would not be permitted. The superintendent informed me that a group of the machines were built by the Jarecki Company for their own use, and if I remember Mr. Conrader's words correctly, their counterpart cannot be found elsewhere.

THE HOLLY LATHE PROBLEM.

Here is also a solution of the problem given in connection with the Holly lathe illustrated on page 172 of the May issue.

One revolution of the triple thread worm on the spindle is equal to three teeth on the worm gear B. $72 \div 3 = 24$, which means that the spindle will make 24 revolutions while B and D are making 1. Assuming that the gears on D and E have the same number of teeth E will make one revolution also. By one revolution of the 16 toothed pinion keyed to the lower end of E the rack is moved 16 teeth, and 16 teeth on a rack of ⅜ inches circular pitch equals 6 inches. We have found that 24 revolutions of the spindle will move the carriage 6 inches when gears having the same number of teeth are used on D and E, which is equivalent to a four pitch lead screw, and the gears can be figured in the usual manner.

With 24 toothed gear on D and 69 toothed gear on E a 11½ pitch thread can be cut, but they are not the only gears that can be used to cut it. The worm gear will be right hand.

A. L. G.

* * *

PUMP TESTS.

The March number of the "Technology Quarterly," a publication of the Massachusetts Institute of Technology, contains, as usual, a summary of some of the tests made in the engineering laboratories of that institution. In this instance there is a collection of tests upon different forms of pumps, and as information of this kind is not easily obtained but is often wanted, it may help some reader if we abstract a few results. Unfortunately, the dimensions of the different apparatus are not given and they must be inferred in a general way from the stated speed and capacity in gallons. A large number of tests were run but as the conditions of head, steam pressure, speed etc., were varied, they cannot be averaged and we will therefore select one representative test from each table. The apparatus used were a duplex, direct-acting pump, a rotary pump, a pulsometer and a Hancock locomotive inspirator.

Duplex Pump.—Single strokes per minute, 94.5; apparent capacity, 400 gallons per minute; actual capacity, 352 gallons; steam pressure (gauge), 40.11; total head, 204.9; horse-power (steam end), 20.6; horse-power (water end), 18.2; efficiency (per cent.), 88.5; steam per horse-power per hour, 73.1; duty, 24,240,000.

Rotary Pump.—Revolutions per minute, 237; capacity, gallons per minute, 843; total head, 91.3; horse-power delivered to pump, 39.7; horse-power delivered by pump, 19.5; efficiency, 49.

Pulsometer.—Capacity, gallons per minute, 74.6; total lift, 27.42; steam pressure, 19.9; temperature at suction, 30.2° C.; at discharge, 35.4° C.; efficiency, per cent., .37; duty (as a pump, neglecting heat transfer), 2,850,000.

Inspirator.—Delivery capacity, gallons, per hour, 878; lift, 4.03 feet; boiler pressure, 105.6 pounds; delivery pressure, 112 pounds; suction temperature, 11° C.; delivery temperature, 65.1° C.; water delivered per pound of steam, 12.

* * *

Next to the diamond carborundum is the hardest substance known. It is a manufactured product of which coke and sand are two ingredients. The substances are treated electrically and with acids.

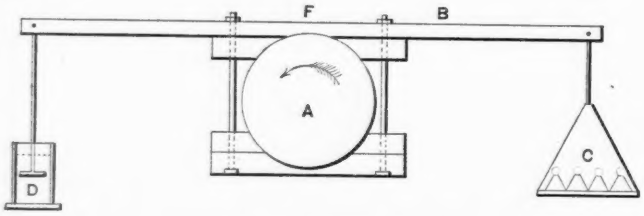
DYNAMOMETERS.—3.

ABSORPTION DYNAMOMETERS.

SAMUEL WEBBER.

In two previous articles I have treated of transmission dynamometers, which registered the power transmitted from a shaft or engine to any machine which required it, and therefore weighed the power actually consumed by that machine.

There is, however, another class of dynamometer which weighs or consumes the power actually produced by any first motor, such as a steam engine, or water-wheel, and which is known as an "absorption dynamometer" from its absorbing the whole power produced, but more commonly called a friction, or "Prony," brake, from the name of the French engineer who applied it practically. The principle is a simple one. It is that it requires just the same power to hold up a weight at the extremity of a lever, or "at arm's end," as it were, by the friction of a pulley, acting on that lever, from a fixed center, as it would to lift that weight steadily, at the velocity at which the point of attachment would move, if it were not restrained by the weight. A common form of this brake or dynamometer was shown in MACHINERY for October, 1897, and its operation explained. so that I need not take up time by any further description of it, but my attention has been recently called to the subject by an article in one of your contemporaries, in which the writer shows what he calls a very simple form of dynamometer, in which the parts seem to me to be unnecessarily duplicated, and I therefore inclose a sketch of the simplest form which I have ever used, and which is very convenient, if you have space enough for your levers.



A SIMPLE FRICTION BRAKE.

This brake admits of being evenly balanced over the center F, with the scale pan empty, on one end, and the piston of the regulator, in water at the dash pot at the other. With a known weight in the scale, it is a simple matter to count the revolutions of the pulley and obtain the foot-lbs.

If, as is often the case, the "horse-power" is the desired point to be obtained, the operation may be very much simplified by making the length of the brake lever, from the center F, to the point of attachment of the weight, the radius of a circle, of either 33, 55 or 66 ft. circumference. If it be of 33 ft., 100 revolutions (per minute) will describe 3,300 ft., and 10 lbs. in the scale will indicate 1-horse-power, and if of 66 ft., 2 HP.

For the 55 ft. circle, the operation is reversed, and the weight in the scale multiplied by 10, divided by the number of seconds occupied in making 100 revolutions gives the HP.

These radii, obtained beforehand, and the lever cut to them, reduce the calculation very much, and ensure accuracy. They will read, if carried out in decimals, 5.2521, 8.7535, and 10.5042 feet respectively, but for all ordinary purposes, the last two decimals may be disregarded, and 5′ 3″, 8′ 9″, and 10′ 6″, taken as the length of the brake lever. The variation from correctness will be less than 1 per cent., and as the late James B. Francis once said to the writer, when discussing this very question of minute accuracy in turbine testing: "What is the use of splitting hairs for the fraction of one per cent. in testing a water-wheel, when the atmospheric variations in a mill make a difference every day of more than 10 per cent. in the power required at different periods of the day?"

I note these points for the benefit of your younger readers, to show them that the measurement of power is not such a very intricate matter, and to encourage them to look into such questions for themselves.

I will only add that this power brake is indispensable, if you wish to find the power actually delivered by a steam engine.

Power from Vertical Shafts.

I have, however, omitted to mention the application of this form of dynamometer to the measurement of the power from a vertical shaft, such as a turbine wheel of the old form of construction, and will close this article with a few words on this point.

In such a case the first form of brake mentioned, a simple pair of clamps, with one long arm, is necessary, and this requires no balancing, but should be supported from above by a "differential block," attached to some support directly over the shaft, with chains long enough to allow the brake to swivel freely. This is done to avoid extra load on the step, as the weight of the friction pulley will usually be equal to that of the bevel gear, which it replaces on the shaft.

The length of the arm of this brake should be according to the dimensions already given, although I once had to use one 15 feet 9 inches long, of the radius of a 99-foot circle, to avoid handling too many weights in the scale. As it was, I had to use about 1200 pounds of pig iron to load down the wheel, which was a very large one. In such a case as this it is also necessary to use gearing to screw up the nut on the brake bolt. In the case referred to the thread of the nut was cut in the hub of a spur gear, some 12 inches diameter, which was driven by a 6-inch pinion, on a shaft which was turned by a 3-foot hand wheel.

The friction pulley was 18 inches face and 6 feet or 7 feet diameter, I forget which, and was lubricated with strong soapsuds at three points on its circumference, besides a jet of cooling water played in through the jaws of the brake.

The motion is transferred from its horizontal direction to a vertical one for weighing by attaching the arm of the brake from its point of pull to the vertical arm of a "bell crank lever," which should be perfectly balanced on its central support. The weighing lever shown above, with the substitution of a vertical arm for the shoe of the brake, is the right thing, and may be made of any convenient dimensions, making its arms of equal length, or in a ratio of two to one, or three to one, if it is an object to save handling weights. This lever may also be made in the form of a reversed L, or carpenter's square ,by balancing off the weight of the horizontal arm by a chain or cord over a pulley overhead.

By way of correction I will say that in the first article of this series the "poise weight" should be 3.84 pounds, instead of 3.04 pounds as printed.

* * *

THE CHINESE FOOT—CHINESE MECHANICAL METHODS.

F. F. HEMENWAY.

The diverse systems of measurement in vogue in China would set the fine-spun American or European mechanic wild with confusion. The standard foot, for example, seems to have something to do with the hand, as it does in this country; or, more correctly speaking, the hand seems to have had something to do with its establishment, but it varies in different localities and as between different trades, between 9½ and 16 inches—English inches—with nothing very certain about it at that. This variation seems to have come through the will of remote public functionaries, who are in rather supreme command concerning these things, as well as others, in the various sections into which the country is divided, although as between different trades in the same section there may be two or three kinds of feet. An idea of the serious inconvenience of this in the matter of internal trade seems never to have entered the head of these public functionaries, who in China are the people.

European and American engineers in charge of the erection of machinery in China manage to keep pretty close to the inch of their tradition, because most of what they have to do with comes from Europe or America, and generally their operations are carried on near some government works in which European practice predominates so far as the mechanics of the matter goes. Sometimes, however, as in ordering something in the way of trimmings from different branches of native manufacture, they must order in stock, so to speak, or the variation in the foot will give them either a wonderful over-supply or a demoralizing famine. The exact specification as to feet is no evidence of what will come to hand.

An American engineer in China was shown, with considerable ceremony, a standard foot measure made about the beginning of the Christian era. It measured about 12 9-16 inches in length. In another instance he was shown a foot standard made in the

year 81. It was of copper and a little less than 9½ English inches in length.

The facility with which the Chinese mechanic—if that is the right name for him—will imitate, is only equalled by the facility with which he will do, or understand, nothing else. The old story of the new trousers, patch and all, from the Chinese tailor, was paralleled in the experience of this engineer. Probably not without some idea of keeping on the favorable side of the Viceroy who wielded power in the locality where he was erecting considerable machinery for the government—machinery made in this country, and for which he had to construct hulls and the like by the aid of Chinese labor—he looked after the construction of a boat of considerable size that was to be towed up and down the river by a hundred or more Chinese laborers, the Viceroy and suit being passengers on tours of inspection. The engineer, with the mechanical instinct of utility, had arranged a pump for raising water for washing decks, etc. Two or four laborers, by oscillating a small shaft, could raise a very considerable quantity of water in a short time; but they never took kindly to the pump. It did not seem to be a way of raising water for such purposes that squared with their traditions.

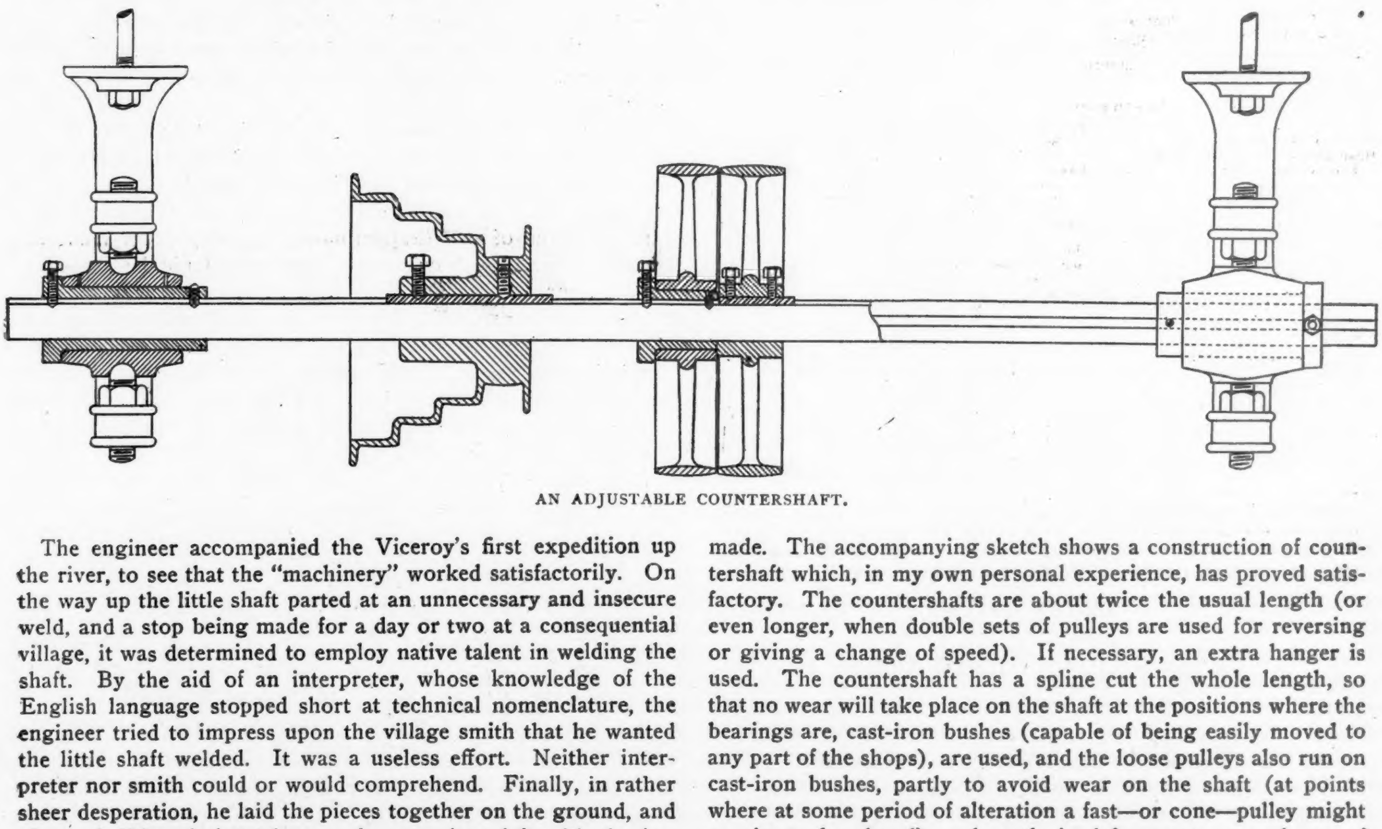
The engineer accompanied the Viceroy's first expedition up the river, to see that the "machinery" worked satisfactorily. On the way up the little shaft parted at an unnecessary and insecure weld, and a stop being made for a day or two at a consequential village, it was determined to employ native talent in welding the shaft. By the aid of an interpreter, whose knowledge of the English language stopped short at technical nomenclature, the engineer tried to impress upon the village smith that he wanted the little shaft welded. It was a useless effort. Neither interpreter nor smith could or would comprehend. Finally, in rather sheer desperation, he laid the pieces together on the ground, and after a half-hour's interchange of pantomime, left with the impression that the smith understood that he wanted a new shaft to replace the broken one. During the forenoon of the next day the smith and his helper appeared at the boat with two packages wrapped in some kind of native grass. The one was the broken shaft, and in the other its exact reproduction, break and all. It has never ceased to be a mystery to the American engineer how that Chinese smith managed to so completely imitate the broken ends of the shaft, rust and all. That is as much a mystery to him as it is why he did imitate it. The reason for the latter is something in the way of Chinese imitation ethics not comprehended by outsiders.

In this engineer's operations there was call for a good many fairly large nails, nothing in the way of a spike being driven. Of these nails, a Chinese carpenter would drive exactly one hundred in a day, and never a nail would he drive without first boring a hole for it. Such ways of working so wrought up the feelings of the engineer, and he gave so vigorous expression to them, that it was thought to be in the interest of his safety that he resign in favor of some one not so particular about driving nails and such trifles. The engineer who succeeded him wisely overlooked the nail-driving business, but he protested so vigorously against other native practices that he found it convenient to take refuge on board a convenient vessel in less than two weeks after attempting to reform Chinese mechanical methods.

MACHINE TOOL COUNTERSHAFTS.

JAMES VOSE.

The countershafts of machine tools have, in my opinion, scarcely received the amount of attention they deserve at the hands of designers. It seems to be usually considered that if a countershaft is long enough to hold the driving cone pulley, the fast and loose pulleys and the hangers, that such provision is all that is necessary. From my experience, however, this arrangement does not allow such an amount of latitude as regards choice of position of the machine tool on the shop floor, and the position of the driving pulley on the main shaft as is desirable. The position of tools already at work, the manner in which the shop ceiling or other arrangements for carrying the countershaft hangers are already occupied, the position of other overhead belts and driving pullies on the main shaft, are all factors which have a knack of interfering with the (at first sight) simple operation of laying down a machine tool in the best position, and fixing a countershaft above it. The extra expense of a countershaft which will allow reasonable latitude in the above respects is, from my experience, fully repaid in the time gained in fixing and starting the tool, and the ease with which rearrangements of tools can be made. The accompanying sketch shows a construction of countershaft which, in my own personal experience, has proved satisfactory. The countershafts are about twice the usual length (or even longer, when double sets of pulleys are used for reversing or giving a change of speed). If necessary, an extra hanger is used. The countershaft has a spline cut the whole length, so that no wear will take place on the shaft at the positions where the bearings are, cast-iron bushes (capable of being easily moved to any part of the shops), are used, and the loose pulleys also run on cast-iron bushes, partly to avoid wear on the shaft (at points where at some period of alteration a fast—or cone—pulley might require to be placed), and partly in deference to a weakness of mine for cast iron running on cast iron, as I find such bearings, if well oiled when first put to work, require very little attention and give a minimum of trouble afterward. A small, but valuable, wrinkle is, however, partly responsible for the good results obtained on such bearings. The outer edges of the bearings (or the bore of loose pulleys) are slightly rounded. A kind of capillary action is thus set up, and unless the bearing is actually flooded, the oil refuses to run out of the bearing or bore of the loose pulley. I am indebted to a work on "The Art of Cotton Spinning," by the late Evan Leigh (a well-known cotton-machine builder years ago), a work, which though perhaps written more than twenty years ago, is still worth reading, on account of the hints concerning machine construction generally, irrespective of the information on cotton spinning. Of course, I do not expect any maker of machine tools to alter his usual construction of countershaft without extra payment in some form, but simply repeat that in many cases I think the alteration a paying investment.



AN ADJUSTABLE COUNTERSHAFT.

* * *

Our contributor, Prof. J. J. Flather, who has been professor of Mechanical Engineering at Purdue University for the past seven years, has been appointed professor of Mechanical Engineering at the University of Minnesota at Minneapolis. He has contributed very materially in building up the work in his department at Purdue, and he will have the best wishes of our readers in his new undertaking.

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JULY, 1898.

TECHNICAL GRADUATES.

The question of the efficiency, or inefficiency, of our technical schools is an ever fruitful one for discussion, and there are as many opinions regarding it as there are people to express them. Its latest phase has taken the form of answers to the question, "Why are our fresh graduates of engineering schools such incapable draftsmen?" which have appeared in at least two technical journals.

Similar questions might be asked and often are asked regarding other lines of work. Managers wonder why these young men are so incapable in the shop, office, or engine room, and it seems to be the impression that, after four years' training, they ought to be able to turn their hands to anything in an efficient manner; if they cannot, then schools and school systems are blamed, and numberless suggestions are made for their improvement.

These views on the part of managers are quite likely to spring from claims made by young graduates, and even by their instructors as well. It is too often claimed that a technical course equips a man in a thorough manner for practical work, making him capable of earning a good-sized salary in any department of his profession.

Such a claim is absurd on the face of it and will do as much to injure the standing of a college as any other one thing. Mechanical engineering, for example, includes the construction of every kind of a machine from windmills to 13-inch guns and full-jeweled watches. It embraces not only machine construction, but the erection of power plants, the superintendence of chemical works and other work of a general character; and in these different branches it includes all sorts of positions from president down to the man who chases castings. It is plainly evident, therefore, that it would be only by rare good luck that a student should secure a position for which he was fully equipped.

What a college can do and does is to ground its men in general principles so that in after years they will be able to wo k understandingly and advance rapidly—though beginning, it may be, at the bottom like everyone else. It does not make "efficient draftsmen," machinists, inspectors, designers, superintendents or efficient anything else, except efficient students, ready to learn practical lessons and to profit by them so well that they will soon become efficient in whatever position they may occupy. A college course is for general training, simply.

Take the subject of drawing. This is one of a large number of general subjects that enters more or less into all branches of mechanical engineering and therefore is one of the subjects that should be included in the general training. In one course of instruction that we have examined the total time devoted to drawing is equivalent to about three months of work at eight hours a day. This time, however, includes all the recitations and lectures, as well as the time spent in the drawing room. It also includes all the instruction in a theoretical course in descriptive geometry and in the course in machine design, by far the larger part of which would be other than drawing board work. It is safe to say that the whole time spent in actual drawing would not exceed two months of similar work in the drawing room.

It is probable that two months' time is all that it is thought best to devote to drawing. Only a small part of the graduates are to become draftsmen and the time must be given to other subjects. Two months' practice, however, will not make a good draftsman out of an untrained hand. He may either make neat drawings, or may draw rapidly, but he will not be able to do both at once, as he must do if he is to be an efficient workman.

Moreover, how can a draftsman be called efficient before he has mastered the details of his line of work? One student might begin by detailing car trucks, another steam engines and another machine tools. They all have had the same course of study, general in its nature, and they all must secure their own special knowledge by practical experience.

We believe the colleges are doing good work and that their graduates are making a satisfactory showing. They are, in the main, securing good positions, and the records show that the average student steadily rises from the time of graduation. If, instead of being asked why students are inefficient when fresh from school, we were asked the more pertinent question, Why are they so efficient after they have had a few years' experience, we should say: Because they have been well grounded in general principles at school and because, at graduation, they have become efficient students, ready to profit by lessons that can be learned only in practical life.

* * *

BYCYCLE TESTS.

The article by Messrs. Eldredge & Preston giving the results of extended bicycle tests made by them at Cornell University, is of timely interest to those who ride the wheel—and they are legion—and particularly to mechanics who are interested in the mechanical efficiency of the different types of wheels and the different gears and tires. The tests were conducted in the interest of no manufacturer, the wheels were obtained in the open market, and the sole incentive for carrying out so elaborate a series of experiments, necessitating, as they did, many weeks of personal labor, was the satisfaction that any true engineer or mechanic experiences in performing a good piece of mechanical work. The results of these tests are given to the public for the first time in this issue of MACHINERY.

The bicycle is probably the most common machine now met with; but up to the present time very little has been known as to what could be expected of it as a machine, except, perhaps, by a few individuals. It has been brought to such a state of perfection that it apparently answers all requirements on the road; and this, of course, must be the final test in any case. There are few machines, however, requiring a greater nicety of construction and finish than the bicycle, and the designer, maker and reader alike demand a better knowledge of what may be expected from these refinements of construction than can be obtained from actual usage. The tests should be at least as precise as the work of construction.

WHAT A MACHINE DESIGNER SHOULD KNOW ABOUT SPRINGS.—2.*

J. BEGTRUP.

Spiral Springs.

The available space for a spring may determine its shape and size. A long straight spring cannot often be used. Fig. 10 shows a spring which may be useful in a limited space. It is supposed to be made of a strip of high carbon crucible steel 1½ inches wide and 1-16 inch thick, and to be spring tempered. The moment of resistance is $1\frac{1}{2}\times(1\text{-}16)^2\times C$, where C is supposed to be 1-6 of the allowable fibre-stress per square inch or the allowable "unit-stress." For C=15,000 we have moment of resistance =88. At A the lever-arm is 4 ins., and the permissible load at B is therefore about $\frac{88}{4}$ = 22 pounds. The moment of bending varies directly as the distance from B; at E and F it is $2\times22=44$. If we imagine the spring divided into a number of small parts or elements there will for each of these be a small deflection at B proportional to the square of its horizontal distance from B. The horizontal deflection at B, due to a single flexible element at F, will be as if that element had been at O. But as the curve of the spring is longer than the straight line from A to B and has a correspondingly greater number of elements the entire horizontal

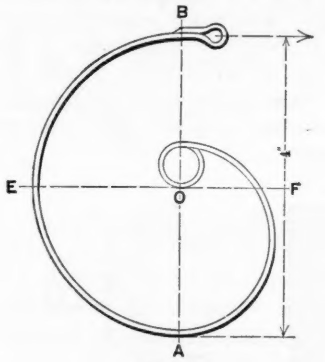


Fig. 10

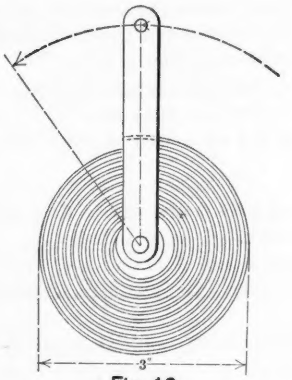


Fig. 12

Fig. 11

deflection at B will be greater than that of a straight spring fixed at A. For a modulus of elasticity of 42,000,000 the deflection at B is about 1¼ inches, or about three times the deflection of a straight spring 4 inches long. A similar spring of same thickness and width, but twice as large, would only carry 11 pounds, but it would deflect $2^2\times1\frac{1}{4}=5$ inches under that load. Generally, for the same thickness and same unit stress the bending deflection of similar springs of this type varies as the square of their lengths.

It will be noticed that the bending moment for different parts of this spring varies considerably, while the moment of resistance is constant. At A the lever-arm is greatest and the unit stress is there at the safe limit, but at other points the spring will be stiffer than necessary; we may therefore improve it by varying the width in proportion to the bending moments; for then the same unit stress is obtained at any point of the length, whereby the deflection is increased without reducing the strength.

Fig. 11 shows the spring when straightened out and shaped so as to give a nearly constant unit stress. This will make the deflection at B about one-third greater.

A great deal of potential energy may be stored in a small space by coiling a strip of steel like the main spring of a watch. If the ends are fixed and guided concentrically the moment of bending will be constant for the whole length; and as the spring can be very long it may be very efficient in a limited space. Fig. 12 represents a spring of this kind. Let W = bending force at end of lever, R = length of lever, S = unit stress, b = width and t = thickness of spring; then

$$W = \frac{S\,b\,t^2}{6\,R}$$

If the spring be made of 1x⅛ inch spring steel and the length of the lever is 6 inches and the unit stress is 96,000 pounds

$$W = \frac{96{,}000\cdot(\frac{1}{8})^2}{6\times6} = 42 \text{ pounds nearly.}$$

* The first article appeared in the May issue.

Let l = length of spring, E = modulus of elasticity and F = deflection or length of arc described by the end of the lever; then

$$F = \frac{12\,l\,W R^2}{E\,b\,t^3}$$

E = 28,000,000 and l = 56 inch gives

$$F = \frac{12\times56\times42\times6^2}{28{,}000{,}000\cdot(\frac{1}{8})^3} = 18\tfrac{1}{2} \text{ inch; that is,}$$

the lever turns nearly one-half revolutions. This result may be had more directly from the formula

$$U = \frac{S\,l}{\pi\,E\,t}$$

where U is the deflection expressed in revolutional and π = 3.14

By substitution as above $U = \frac{96{,}000\times56\times8}{\pi\times28{,}000{,}000} = .49$, or nearly one-half revolution, which agrees with the former result. From this formula it appears that the deflection for a given unit stress varies directly as the length and inversely as the thickness and is independent of the width of the spring. If we had this spring 1-16 inch thick the lever could be turned nearly a whole revolution, but the force would only be 10½ pounds. If we then had twice as many turns in the spiral the lever would turn nearly two revolutions before the limit of stress was reached. Such

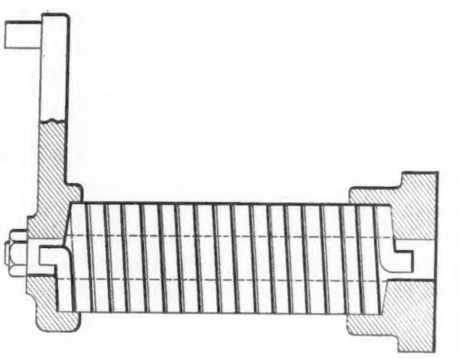


FIG. 13.

springs may also be useful when a nearly constant pressure through a shorter motion is desired, for this can be obtained by a considerable initial deflection. The great efficiency of watch springs is no doubt due to the high elastic limit and careful treatment of the steel. It is sometimes preferable to coil the spring in a screw-line, as shown in Fig. 13. As in the former case, the motion is supposed to be about a fixed center, and the same formulas may be used in both cases. Let there be 72 inches of ¼ inch square spring steel, and let the lever be 3 inches long, then $W = \frac{96{,}000\cdot(\frac{1}{4})^3}{6\times3} = 83$ pounds. Here $(\frac{1}{4})^3$ is the width multiplied by the thickness squared. We have for this spring U $= \frac{96{,}000\times72\times4}{\pi\times28{,}000{,}000} = \frac{5}{16}$ of one revolution of the lever, which is the maximum allowable motion for a unit stress of 96,000 pounds. For round steel $W = \frac{S\,\pi\,t^3}{32\,R} = \frac{S\,t^3}{10\,R}$ nearly. Therefore if this spring is made of ¼ inch round steel $W = \frac{96{,}000}{10.3.4^3} =$ 50 pounds. Round steel has only 3-5 of the strength of square steel of same diameter under bending action, but the value of U is the same in both cases.

The various springs treated of here are all of uniform thickness throughout their entire length. Good results may also be obtained by varying the thickness of a spring so as to correspond with a variable bending moment; but as such springs cannot be rolled to shape and can only receive the correct shape by skillful hand work they are very little used. The forging down of the ends of flat springs is a simple matter and is often done. It improves the appearance of leaf springs and is probably preferable to blunt ends.

The springs treated so far all work by bending. In the next number I shall discuss springs which are twisted, and this will conclude the subject.

THE MECHANISM OF GEAR-CUTTING MACHINES.—2.

FEEDING MECHANISM.

L. D. Burlingame.

The feed mechanism of a gear cutting machine consists of the necessary parts for advancing the cutter through the work, reversing it, returning it at an increased speed, and allowing time for indexing before repeating the operation of cutting. The cutter on its return is either carried far enough by the work to allow time for indexing while the cutter is again advancing for the next cut and before it reaches the blank, or held stationary just beyond the blank while the indexing is going on, and then started on its forward movement after the indexing is completed.

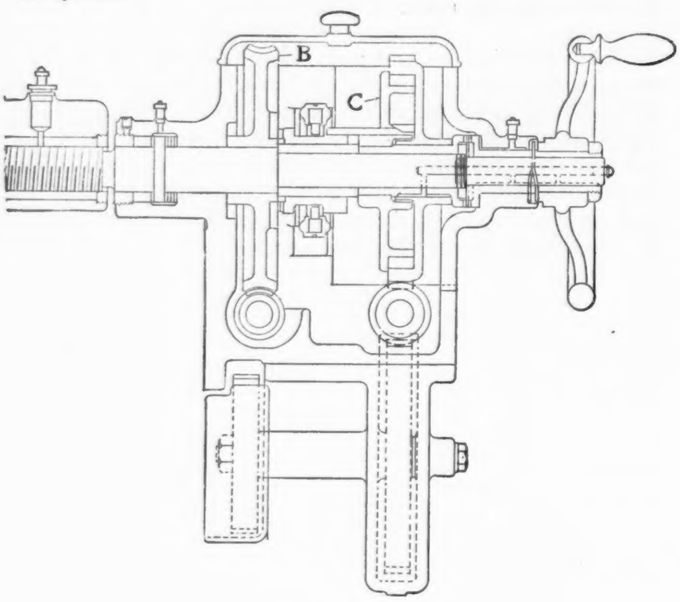


FIG. 13.

If it can be so arranged the quick return should be at a constant speed and not vary with the change of the feed. If the rate of return is constant it can be run at all times at its highest efficiency. On bevel gear cutting machines and on machines of a type where the cutter slide travels in a vertical plane, when cutting spur gears, the return cannot be as rapid (unless counter-weighted) as on machines with a horizontal slide for the cutter, as in the latter case there is no weight to lift. When the cutter slide is returned at a speed of 20 feet or more per minute, it is desirable to relieve the parts of all unnecessary work.

It is ncessary to have a wide range of feeds to each speed of the cutter in order to get the most work from a machine. This is usually accomplished by the use of change gears or cone pulleys.

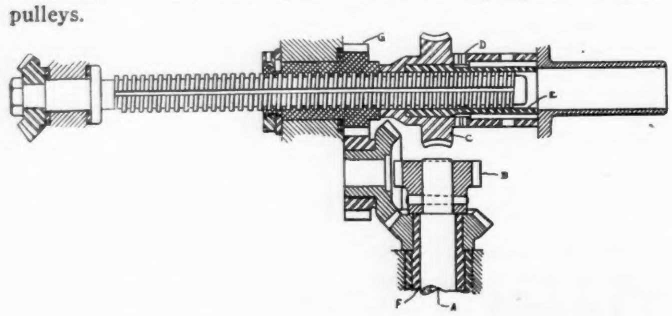


FIG 14.

The types of feed used on well known gear cutting machines may be divided into groups much as for the kinds of indexing. The cutter slide is fed in different machines by a screw, rack, cam or crank, all of which are capable of giving the required quick return motion.

In the Brown & Sharpe spur gear cutting machine, the cutter slide is fed by a screw and the advance for cutting is through a worm to a worm wheel, B, Fig. 13, on the screw; the worm wheel driving the screw through a clutch keyed to the screw. On the other end of the sliding clutch is a finger which engages the friction ring in the quick running return gear, C, so that when the feed is thrown out by the disengaging of the clutch teeth, the friction takes hold and rapidly returns the slide without shock at starting or stopping. This is an advantage of the friction over a positive toothed clutch in such a place. The sliding clutch can be readily locked in a central position where it is disengaged from both gears. This stops the power feed and allows for feeding by hand.

In the Brown & Sharpe bevel gear cutting machines the advance feed is through the shaft, A, Fig. 14, and through a pinion below the pinion, B, to the worm wheel, C, by means of a worm below the wheel, the clutch, D, being engaged with the worm wheel. The clutch is keyed to the sleeve, E, which in turn is keyed to the screw, the key sliding freely in the keyway shown in the screw. When the clutch is thrown out of engagement the hand feed can be operated. The quick return is through the sleeve, F, and the gears shown to the gear, G, which is a threaded nut acting upon the screw.

In characteristic Gould & Eberhardt machines the screw does not revolve, but is held stationary in the cutter slide. The nut A has a gear B mounted on it (see Fig. 15), and the revolving of the nut by means of the gear gives motion to the slide. The slow advance is obtained through the worm and wheel C in clutched engagement with the gear on the thimble D, which in turn drives the gear on the nut. The quick return is similarly operated when the thimble is thrown into clutch with the gear E on the other side.

A friction return is used in some of the Gould & Eberhardt machines; they also build a machine in which the cutter slide is fed by a rack in place of a screw.

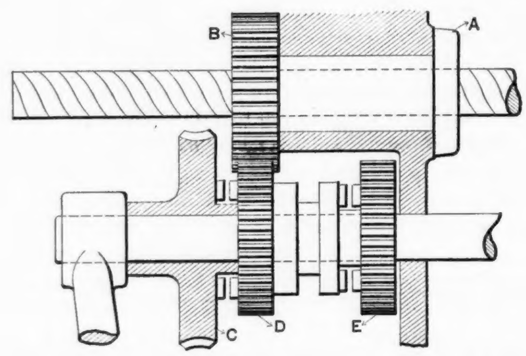


FIG. 15.

In the Pratt & Whitney machines the cutter slide is fed by means of a screw, the advance being (on some of their machines) through sun and planet or epicyclic gears, see Fig. 16, which may be thrown out of engagement by a clutch so that the cutter may be returned rapidly by hand.

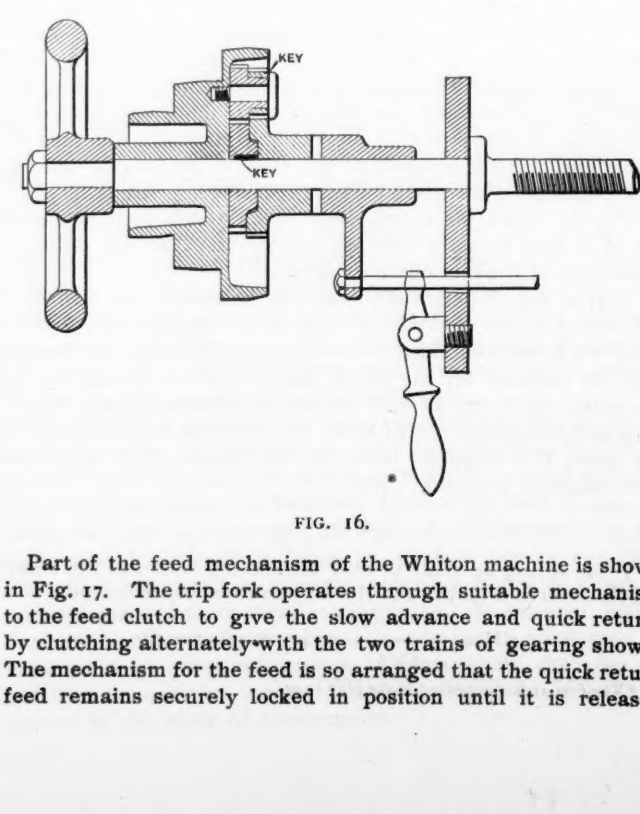


FIG. 16.

Part of the feed mechanism of the Whiton machine is shown in Fig. 17. The trip fork operates through suitable mechanism to the feed clutch to give the slow advance and quick return, by clutching alternately with the two trains of gearing shown. The mechanism for the feed is so arranged that the quick return feed remains securely locked in position until it is released

by the completion of the advance feed. This was designed, as was also the feature of keeping the indexing locked, until the completion of the return movement, with the intention of overcoming a trouble which formerly existed on some gear cutting machines, where there was a possibility of the indexing starting or stopping at an unfortunate time. As far as I know, however, safety in these respects is now assured on leading makes of gear cutting machines. With any automatic machine, no matter what safeguards are provided, intelligent care must be exercised to avoid work being spoiled.

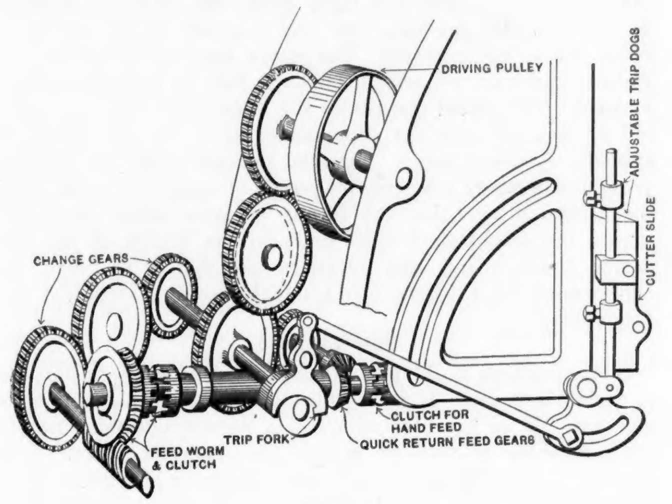


FIG. 17.

The Dwight slate machine is fed with a cam which also gives the quick return. Several cams are provided to give the different or stopping at an unfortunate time. As far as I know, how-lengths of feed required. The sketch, Fig. 18, illustrates the general arrangement.

The Hastings machine is fed by a crank motion similar to that which gives the slow advance and quick return of a slotting machine, as shown in sketch Fig. 19.

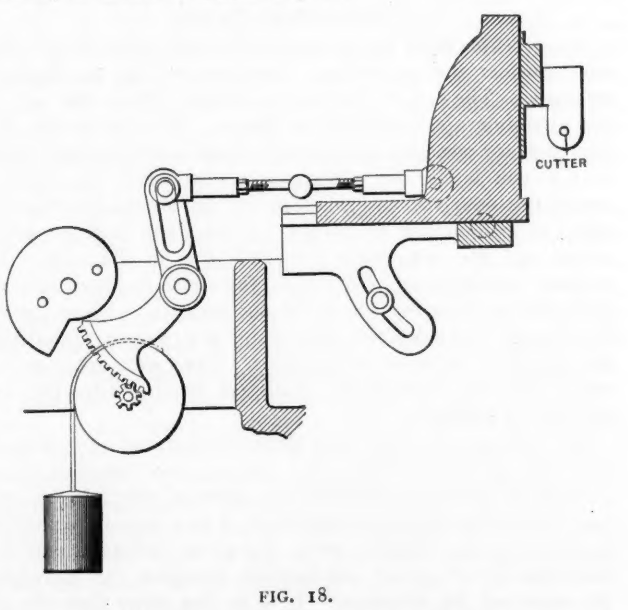


FIG. 18.

Some of the features described in this article are covered by patents and are the outgrowth of years of experience and experiment on the part of their respective builders.

The field for gear cutting machinery is broadening and the fact that accurate cut gears can now be produced so rapidly and cheaply is helping to extend their use. This is shown by the large demand for gear cutting machinery at the present day.

* * *

A forged ring of steel 10 feet 4 inches in diameter, 4 feet high and 5 feet thick is no mean job, even for a concern like the Bethlehem Iron and Steel Company. At the power plant at Niagara Falls the turbines and generators are arranged on vertical shafts, and to serve as a fly-wheel there rings are used. They surround the field magnets, which revolve with the ring, the armatures being stationary.

FACTS ABOUT PATENTS.

EXTRACTS FROM THE PAPER PRESENTED AT THE SUMMER MEETING OF THE A. S. M. E., BY JAMES W. SEE.

Among the various papers presented at the recent meetings of the American Society of Mechanical Engineers the one upon the subject of patents by James W. See, the author of the far-famed Chordal Letters, was undoubtedly of the greatest interest and value to the average reader. This paper is long and space does not permit its publication as a whole; but below will be found nine of the most important divisions of the paper, some of them entire and others in part:

Hurried Applications.

Many inventors produce an invention and then seek a patent without delay, the result often being that the invention is patented in half-baked condition and must be followed up by later patents on more perfected forms, and that commercial experience may prove the invention a failure, and often the premature application results in such exposures as will preclude the later getting of patents with claims of adequate scope. The only advantage of the prompt application is that it enables an inventor to ascertain whether or not he is working in an old field. An application filed merely for the purpose of ascertaining the state of the prior art had often better be allowed to slumber while the invention is being mechanically and commercially developed. An inventor loses none of his rights by delaying his application for a patent. The law gives the inventor a period not exceeding two years in which to publicly exploit his invention before applying for his patent. He may sell the patented invention by the thousands without affecting his rights to the patent, so long as he applies for it within two years from its first publication by print or sale. During this period he may test the market and may improve his invention, and when he applies for his patent the effect of the delay has been to give a later date to the patent, thus prolonging the date of its expiration nearly two years. If infringements develop during the period in question, then it may become advisable to avoid further delay in applying for the patent.

An exception should be noted regarding this matter of delay-

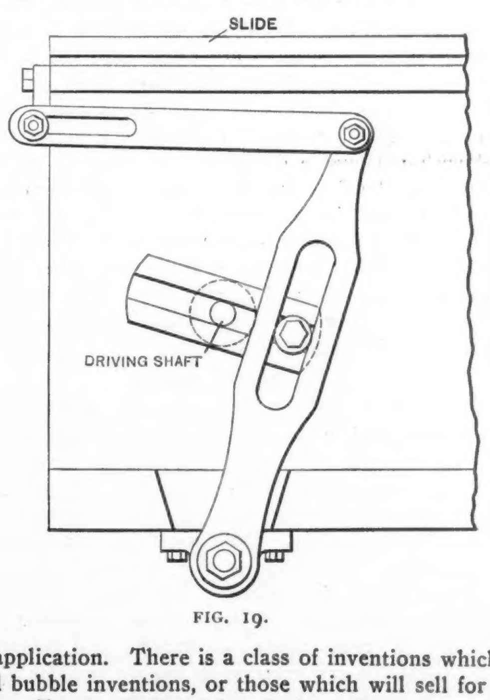


FIG. 19.

ing the application. There is a class of inventions which might be called bubble inventions, or those which will sell for a short time only. Toys and advertising devices often come under this head. Such an invention, if put upon the market without patent, might provoke enterprising competitors having superior facilities and capable of getting all of the cream off of the business before the patent could be procured. Such inventions should be patented before they are exploited.

Stealing Inventions..

Ideas can be stolen from the originator. But there is no excuse for inventions being stolen. Many men have ideas which are mere visions and which never can be given form by anybody; other men have ideas which they would be incapable of reducing to form themselves, but which could be reduced to

form by others if the idea was disclosed. The mere hint or idea is of no benefit to the public, and is not the thing which the law seeks to reward. The useful invention is the thing which is recognized.

Regardless of who first conceives of the desirability of an invention, he who actually makes the invention first is the one entitled to a reward. If the inventor of an idea does not wish to be beaten out of the reward let him keep the idea secret and act upon it. The idea of an invention, followed by occasional and half-hearted attempts to reduce the thing to the form of an invention, will not prevail against the meritorious inventor who, though later to conceive, or even borrowing the idea, was the first to reach the goal of practical accomplishment which benefits the world.

But if an inventor has gone further than the idea, and has developed it into an invention, then the only way he can lose his right is to keep it secret, so that he cannot prove that he had any rights. The originator of an invention who has reduced it to an actual useful invention, and can prove that fact, cannot be deprived of his rights. A competing inventor may meet him in the patent office with an application, or the competing inventor may actually get his patent before the meritorious inventor has applied for his patent, but if the facts are susceptible of proof, the meritorious inventor, after proper interference proceedings, will be adjudged his rights and will get his patent, and the patent of his competitor will be practically void.

Briefly, then, keep ideas of invention secret, for fear a more enterprising man acting on that idea may be the first to actually evolve an invention from it; be not so secret as to exclude knowledge from friends who may be needed to make proof of dates and diligence; be diligent in reducing an idea to a practical invention; when the idea is reduced to a practical invention, avoid secrecy so as to have ample proof of that fact.

First Inventor.

In conflicts between interfering inventors, both seeking a patent on the same invention, he is the first inventor and entitled to the patent who has best done his duty by the public whose reward he seeks. This duty cannot be measured by any fixed standard, and each case must stand largely on its own merit. If an inventor has been diligent in pushing his conceived invention forward into a condition where it is in a position to advance the useful arts, he is not to be deprived of his reward by dilatory earlier conceivers, who have gone only so far as mere disclosures or sketches or drawings, or abandoned experiments or abandoned caveats. Priority of conception must be coupled with reasonable diligence. If there is no negligence on the part of the first inventor, the second inventor, though the first to reduce the invention to practice, will not prevail. An application for a patent is construed in law to be a reduction to practice. The first inventor is, therefore, either he who first conceives the invention and follows it up with reasonable diligence, or he who conceives later than a negligent inventor and first reduces the invention to practice.

Employers' Rights.

An invention, to be patented, must be applied for by the actual inventor, and in the absence of acts constituting a transfer, the patent, and all legal ownership in it, and all rights under it, go exclusively to the inventor. In the absence of express or implied contract a mere employer of the inventor has no rights under the patent. Only contracts or assignments give to the employer, or to anyone else, a license or a partial or entire ownership in the patent. The equity of this may be appreciated by examples. A journeyman carpenter invents an improvement in chronometer escapements and patents it. The man who owns the carpenter shop has no shadow of claim on or under this patent. Again, the carpenter invents and patents an improvement in jack-planes. The shop owner has no rights in or under the patent. Again, the carpenter invents an improvement in window frames, and the shop owner has no rights. He has no right even to make the patented window frame without license. The shop owner, in merely employing the carpenter, acquires no rights to the carpenter's patented inventions. But there are cases in which an implied license would go to the shop owner. For instance, if the carpenter was employed on the mutual understanding that he was particularly ingenious in devising carpenter work, and capable of improving upon the products of the shop; and if in the course of his work, he devised a new and patentable window frame, and developed it in connection with his employment and at the expense of his employer; and if the new frames were made by the employr without protest by the carpenter, the carpenter could, of course, patent the new frame, but he could not oust the employer in his right to continue making the invention, for it would be held that the employer had acquired an implied license.

If he could not use it, then he would not be getting the very advantage for which he employed this particular carpenter, and if he did get that right he would be getting all that he employed the carpenter for, and that right would not be at all lessened by the fact that the carpenter had a patent under which he could license other people. The patent does not constitute the right to make or use or sell, for such right is enjoyed without a patent. The patent constitutes the "exclusive" right to make, sell or use, and this the shop owner does not get unless he specially bargains for it. Implied licenses stand on delicate ground, and where men employ people of ingenious talent, with the understanding that the results of such talent developed during the employment shall inure to the benefit of the employer, there is only one safeguard and that is to found the employment on a contract unmistakably setting forth the understanding.

New Purpose.

If an invention is old, it is old regardless of any new purpose to which it is put. It is no invention to put a machine to a new use. If an inventor contrives a meritorious machine for the production of coins or medals, his invention is lacking in novelty if it should appear that such a machine had before been designed as a soap press, and this fact is not altered by any merely structural or formal difference, such as indifference in power or strength, due to the difference in duty. The invention resides in the machine and not in the use of it. If the soap press is covered by an existing patent, that patent is infringed by a machine embodying that invention, regardless of whether the infringing machine be used for pressing soap or silver. And it is no invention to discover some new capacity in an old invention. An inventor is entitled to all the capacities of his invention.

Combination Claims.

Many people have an erroneous idea regarding patent claims, and consider the expression "combination" as an element of weakness. The fact is, that all mechanical claims that are good for anything are combination claims. The erroneous public contempt for combination claims is based upon the legal maxim, that if you break the combination you avoid the claim and escape infringement, and this legal maxim should be well understood in formulating the claims. If the claim calls for five elements and the competitor can omit one of the elements, he escapes infringement. Therefore, the claim is good only when it recites no elements which are not essential. Many inventors labor under the delusion that a claim is strong in proportion to the extent of its array of elements. The exact opposite is the truth, and that claim is the strongest which recites the fewest number of elements.

The invention having been carefully analyzed and reduced to its prime factors, and the claim having been provided to comprise a combination involving no element which is not essential to a realization of the invention, a new and more important question arises. Cannot some ingenious infringer realize the invention by a similar combination escaping the literalism of the terms of the elements? It is at this stage that the claim must be carefully studied. The inventor, or some one for him, must assume the position of a pirate, and set his wits to work to contrive an organization realizing the invention but escaping the terms of the proposed claim. When such an escaping device is schemed out, then the defect in the claim is developed and the claim must be redrawn. In this way every possible escape must be studied so as to secure to the inventor adequate protection for his invention. Briefly, then, all good claims for mechanism are combination claims; the fewer the elements recited the stronger will the claim be; non-essential elements weaken or destroy the claim; the claim should not be considered satisfactory so long as a way is seen for the escape of the ingenious pirate.

Combinations and Aggregations.

A given association of mechanical elements may be entirely new, but it does not follow that it forms a patentable associa-

tion, for not all new things are patentable. If the new association is a combination it is patentable, but if it is a mere aggregation it is unpatentable. An association may be new and still all of its separate elements may be old, the act of invention lying in the fact that the elements have been so associated with relation to each other as to bring about an improved result, or an improved means for an old result. All new machines are, after all, composed of old elements. The law presupposes that the elements are old, and that the invention resides in the peculiar association of them. If we take a given mechanical element, recognized as having had a certain capacity, and if we then similarly take some other mechanical element and employ it only for its previously recognized capacity, and if we then add the third element for its recognized capacity, we have in the end only an association of three elements each performing its well-recognized individual office, and the entire association performing only the sum of the recognized individual elements. Such an association is a mere aggregation, a mere adding together of elements, without making the sum of the results any greater in the association than it was in the individual elements. It is simply adding two to one and getting three as a result. An aggregation is unpatentable. As an illustration, a heavy marble statue of Jupiter is found in the parlor and is difficult to move. Ordinary castors are put under its pedestal and it becomes easier to move. Modern anti-friction two-wheeled castors are substituted for the commoner castors, and the statue becomes still easier to move. Castors were never before associated with a statue of Jupiter. Here is a new association, but it is a mere aggregation. The statue of Jupiter has been unmodified by the presence of the castors, and the castors perform precisely the same under the statue of Jupiter that they did under the bedstead. There is no combined result, and there is no patentable combination.

But if the inventor takes a given mechanical element for the purpose of its well recognized capacity, and then associates with it another mechanical element for its recognized capacity, but so associates the two elements that one has a modifying effect upon the capacity of the other element, then the association will be capable of a result greater than the sum of the results for the individual elements. This excessive result is not due to the individual elements, but to the combination of them. One has been added to one and a sum greater than two has been secured. In a patentable combination the separate elements mutually act upon each other to effect a modification of their previous individual results, and secure a conjoint result greater than the sum of the individual results.

As an illustration, assume an old watch in which there was a stem for setting the hands, and assume another old watch with a stem for winding the spring. If an inventor should make a watch, and provide it with the two stems, he would have only an aggregation. But if he employed but one stem, and so located it that it could be used at will for setting the hands, or for winding the spring, then he would have produced a combination. The particular instance just given is not a case of the same number of elements, producing a result in excess of the individual results of the separate elements, but is rather a case of a lesser number of elements, producing a combination result equal to the sum of the previous results of a greater number of elements. A better example would perhaps be a new watch with its two old stems so rotated that either could be used for setting the hands, or for winding the spring.

Mechanical Equivalents.

Where an inventor produces a new mechanical device for the production of a certain result, he can often see in advance that various modifications of it can be made to bring about the same result, and even if he does not see it he may in the future find competitors getting at the result by a different construction. He analyzes the competing structure, and determines that "it is the same thing only different," and wonders what the legal doctrine of mechanical equivalents means, and asks if he is not entitled to the benefits of that doctrine, so that his patent may dominate the competing machine.

If the new result cannot be produced by any other combination of elements, then, of course, no question will arise regarding infringement. But it may be that a competitor contrives a device having some of the elements of the combination as called for by his claim, the remaining elements being omitted and substitutes provided. The competing device will thus not respond to the language of the claim. But the courts will deal liberally with the claim of the meritorious pioneer inventor, and will apply to it the doctrine of mechanical equivalents, and will hold the claim to be infringed by a combination containing all of the elements recited in the claim, or containing some of them, and mechanical equivalents for the rest of them. Were it not for this liberal doctrine the pioneer inventor could gather little fruit from his patent, for the patent could be avoided, perhaps, by the mere substitution of a wedge for the screw or lever, called for by the claim. The Court, having ascertained from the prior art that the inventor is entitled to invoke the doctrine of equivalents, will proceed to ascertain if the substituted elements are real equivalents. A given omitted element will be considered in connection with its substitute element, and if the substitute element is found to be an element acting in substantially the same manner for the production of substantially the same individual result, and if it be found that the prior art has recognized the equivalency of the two individual elements, then the court will say that the substituted element is a mechanical equivalent, and that the two combinations are substantially the same. This reasoning must be applied to each of the omitted elements for which substitutes have been furnished. In this way justice can be done to the pioneer inventor. But the courts, in exercising liberality, cannot do violence to the language of the claim. The infringer will not escape by merely substituting equivalents for recited elements, but he will escape if he omits a recited element and supplies no substitute, for the courts will not read out of a claim an element which the patentee has deliberately put into the claim, and a combination of a less number of elements than that recited in the claim is not the combination called for by the claim.

Divisional Patents.

It may not be possible to cover the several segregable features of a given machine in a single patent. The law contemplates a patent for an invention and not for a number of inventions. A bicycle may be invented which is new and patentable viewed as a whole structure. In such case the claim would recite all of the elements essentially involved in the new organization. But in this bicycle the pneumatic tire may of itself be new and patentable, and the wheel may be of a novel construction, and the lock-nut may be new, and the driving-chain may be new, and there may be a new means for securing the joints of the tubing. These matters cannot be covered in one patent. The improved tire would be viewed as being entirely independent of the peculiarity of the bicycle, and would be susceptible of employment on other kinds of bicycles and vehicles; the wheel construction might be employed in other kinds of bicycles or in wheelbarrows; the chain might be employed in varying situations calling for the use of driving chains. In the Patent Office the wheel of a bicycle is not treated as a bicycle wheel, but as a wheel, for any purpose for which it may be suited. A bicycle chain is not called a bicycle chain, and applications for patents on chains are not examined by the examiner who examines bicycle applications. Lock-nuts constitute a sub-class by themselves. The fact that the arts have recognized these separate sub-classes of devices, and that the Patent Office classification of inventions deals with them as separate and independent elements in the arts, and that the examining divisions of the Patent Office deal exclusively with given matters, all these facts go to the merit of the question of division of application. The single patent can cover only such matters as are necessarily interrelated to each other. The patent on the bicycle can cover the improved lock-nut in its combination relationship to the other features of the bicycle, but it cannot contain a claim covering the lock-nut by itself.

An Additional Point.

In commenting upon Mr. See's paper, the "Engineering News" calls attention to the matter of making preliminary examinations bv searching the records. Previous to the reduction in the price of printed copies of patents this process was necessarily very laborious, as the expense incurred in obtaining all the copies of any one class was altogether too great. At present, as stated in the "News," "a pamphlet, published by the Patent Office and sold at 10 cents per copy, contains a complete classification of all the subjects of invention, and should be in every engineer's library. Suppose it is desired to see whether

some new device in connection with the continuous heating of trains by steam from the locomotive is old. Turning to the pamphlet above referred to, we find that this is under Class 126, Stoves and Furnaces, and that it is Sub-Class No. 129, under Heating Systems—Train—Steam; also that the number of patents issued to date in this sub-class is 117. Where all the patents in a sub-class are ordered, the price is only 3 cents per copy. Thus by sending the sum of $3.51 to the Patent Office, this whole set of patents can be obtained, constituting a complete record of what has been accomplished in this field by every inventor who has thought enough of his work to obtain a United States patent.

"Of course, it is not always easy to determine under exactly what sub-class a given device will be placed, and it is sometimes advisable to purchase the patents in two or three sub-classes. But it will almost always be found that the money thus spent is well spent. The information thus obtained may make it clear that a device is so far from novel that no patent of any value could be obtained, or may so enlighten an inventor as to what others working in the same field have done that he will be able to put his own device in far better shape before putting it into use or applying for a patent upon it.

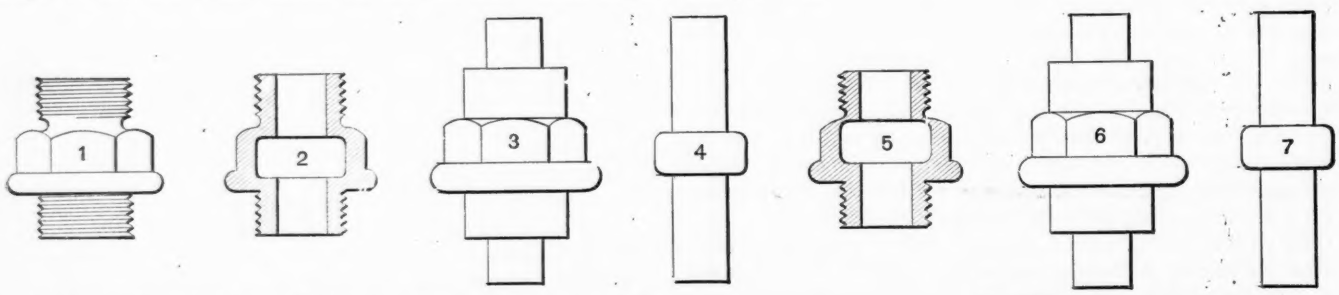
"It is true, of course, that the present classification is by no means perfect, and that errors sometimes occur through the means pointed out in Mr. See's paper. On the other hand, any search, even that of the Patent Office examiners, is only approximate; and if the file of patents in the sub-class to which an invention belongs is searched through without finding anticipations, there is a strong probability that the invention is novel."

* * *

SCIENCE VS. MAIN STRENGTH.

BEEN THERE.

I was once employed to "improve methods" in the factory of a concern manufacturing steam goods, and as I had been successful in the same line elsewhere, and was to get higher wages in the new place, started on the job with considerable enthusiasm. The first* case I attempted can be understood by reference to the cuts, in which Fig. 1 is a part of a union, the bottom part screwing into the body of the apparatus, and the top part taking the coupling nut. Fig. 2 shows the inside of the piece, and it will be seen that the distance from the chambered part to the top of the piece is slightly more than the distance down. Fig. 3 shows the pattern, and Fig. 4 the core, and it will be seen that the top part of the core is longer than the bottom part, just enough to make up for the difference shown in Fig. 2, because the pattern was made with core prints projecting the same distance from the top and bottom.



The consequence of this was that a certain number of cores were pretty sure to be reversed when they were set in the molds, with the result that the finished pieces would come like Fig. 5, where it is easily seen that the castings almost cut through in finishing; if they had cut clear through it would have been better, as they would then have been discovered at once, instead of waiting until some man was scalded by escaping steam after they had broken in use.

As I was hired with "full authority" to make improvements, I at once gave orders to have the patterns and core boxes changed so that the top core print would be shorter than the bottom one, and both end of the core would be the same length, as shown in Figs. 6 and 7. It would then be simply impossible to get the cores set wrong and the trouble would take care of itself and disappear forever.

When I went around soon after with a feeling of pride that I had overcome the first trouble so easily to see how the improvement was progressing, I found that the whole thing had been ordered stopped by the very man who hired me to make the improvements.

On seeking an explanation I was informed that "the patterns are all right; I had those patterns made and they aint going to be changed; the gol-blame molders have got to set them cores right, or I will fire every man in the foundry."

All arguments were useless, and this was my first lesson in the experience that now teaches me that it is sometimes well to make haste slowly. Of course it wasn't long before I decided that my efforts were not appreciated, and therefore "accepted another position" (which being rendered into truthful shop language, means that I hustled around and got another job).

But that is neither here nor there. The principal object of this article is to show what seems to me to be true; that it is better to run a factory by scientific methods than by main strength; making patterns so the castings will come right, in spite of a molder, is better than making patterns so the molder must take great care to get the castings right; making tools so the work will come right is better than making them so the workman must spend half his time wondering how the work is coming out, and so on to the end of the chapter.

A first-class pattern maker would have made the patterns in question in the first place so that the cores could not be set wrong, rather than make them so they would look pretty, or look like the patterns that some other fellow had made; it is no sin to have one core print on a pattern longer than another core print, if any good is accomplished by having it so. It is better to make a pattern to mold easily, even if the casting weighs a little more, provided that the cost per pound is reduced enough to make the price of the whole casting less.

Slight changes in patterns and tools will often accomplish wonders, and no man, in these days of sharp competition, can afford to let any feeling of price or jealousy stand between him and progress.

* And last.

NOTES.

It doesn't pay to make screw threads a little different from standard in order to compel customers to order all repairs from the firm who built the machine. Some firms still do this and we don't believe they get enough extra repair work to pay for the increased first cost of the tools. If the machines are made on the duplicate plan parts will generally be ordered from the parent concern in any case; and when they are not ordered from them it will be because there is immediate need for quick repairs. To try to make it impossible for customers to have these quick repairs done is not working in the interests of one's customers.

* * *

About the most exasperating thing in machine work is to have parts reach the erecting floor that have not been carefully looked over by some one who knows enough to tell whether they are in proper condition. Lack of oil holes, oil runs, the binding of a pin head upon a lever, or of a pin in a bearing—such trivial things should be attended to somewhere else besides on the erecting floor. They take a great deal of time and hand labor to rectify, and it is not fair to the foreman of the erecting floor to have to charge time to such work, nor does it help him to have a row of frames standing on the floor for a long time and apparently nothing being added to them. The foreman of this department needs a good stiff backbone to hold out against such practices and to prevent being imposed upon. No foreman likes to have much of this fitting charged in his department, and there is likely to be many a squabble before the matter is settled.

SINGLE POINTED AND MANY POINTED CUTTING TOOLS.

BELL CRANK.

For many years there has been a wide difference of opinion among mechanics as to the comparative efficiency of milling and planing, and it will help to a clearer understanding of the matter to make a careful examination of the principles involved in the cutting of metals. A cutting tool is simply a wedge driven into the material for the purpose of separating it, and the thinner the wedge the easier it drives in. It is important to move the tool or the material at the most effective speed, which is limited by the heating and softening of the cutting edge, due to friction.

The only way the heat generated in cutting can be got away from the tool point is by conduction through the tool point to the body, and thus to the air, by direct radiation to the air and by a cooling liquid. The thin edged tool cuts easiest, not because of less friction in contact with the material, but because it distorts the material less while removing it. The tool edge must be thick enough to have necessary strength, and for heavy cuts it must have a point of sufficient width and cross section to conduct away the heat rapidly. To make it most effective both the tool and the work must be held so there will be the least possible vibration, for vibration is equivalent to sudden increases of speed at rapid intervals and heats the tool point. Another essential of easy and accurate cutting is that the chip be thick enough to prevent the tool gliding over the surface, cutting in a few places only.

The planer and milling machine can be equal in regard to rigidity of table and means of holding the work, and the difference must be due entirely to the cutting process. A planer is usually well arranged to hold the tool rigidly against the thrust of the work, and the tool has a good cutting rake and small clearance. The tool cuts only two-thirds of the time, and this gives the tool a chance to cool off. The planer, therefore, can easily have all the conditions favorable to good cutting effect. To make the milling cutter equal to the planer tool it should have the same rake and clearance and be held just as rigidly. Each tooth should take a cut at least two-thirds as thick as the planer tool takes. The teeth on the cutter should be far enough apart to permit the chips to get out without crowding. It is almost certain that the most effective milling cutter will not have more than two teeth cutting at one time, except in the case of face mills.

If all these conditions were obtained the milling cutter would be superior to the planer tool, because each tooth would be cutting but about one-sixth of the time and would have time to cool off, thus allowing a higher cutting speed to be attained. Each tooth would be taking a cut of two-thirds that of the planer tool if one tooth at a time were cutting, or one-third as thick if two teeth were cutting; and finally, if a lubricant is used, each tooth of the cutter would be lubricated ready for action. Here are three distinct advantages over the planer tool, all permitting a higher speed, and should result in doing one-half more work.

The cold chisel and file are examples of the two extremes of cutting, one with a single cutter and the other with a large number of cutting edges. If very much stock is to be taken off by hand, no one would hesitate in choosing a chisel in preference to a file. It takes more force to remove the same amount of stock with a file, because so much force is used up in shaving it all into fine chips. We do not want the fine chips, but we use a file because we can make a true surface with it easier than with a chisel.

The lesson the single pointed tool teaches is that a cylindrical milling cutter should have as few teeth as it is possible to have, and yet keep one, or at most two, teeth cutting at a time. It would probably not be practical to have more than two teeth cutting at once, because the chips could not get out without crowding, and I think the most material could be cut off by having but one tooth in action with a chip as thick as a planer or lathe tool takes.

A face mill is favorable to ideal conditions of cutting, for nearly half of the teeth can be in action at once and the total feed increased in direct proportion to the number of teeth in action. The cutting speed could be greater than a lathe, because the cutters have half the time to cool. Supposing the face mill to have cutters on it of the same rake and clearance as a planer tool, held as rigidly and driven with the same power, I am sure that for plane surfaces the amount of work done would be far beyond anything ever yet produced, and from four to six times that possible on the planer. It would be as much superior to the planer in productive capacity as a gang plow is to one taking a single furrow.

The planer could only approach it by using a number of tools arranged like gang plows, but it could not equal the mill, because it could not attain the speed and would lose additional time at each end of the stroke. The gang-of-tools plan has been in use on lathes for some kinds of work for many years, and on planers in an expensive way by having two tool heads on the cross rail, but even the lathe could not do as much work as the milling cutter with an equal number of cutting points in action, because the milling cutters would have half the time to cool off. This is a very important advantage that the milling tool has over every other form of cutter, and should always be remembered when comparing with other forms. True, the planer tool gets a chance to cool off, but it is done entirely at the expense of time lost, which the milling cutter saves.

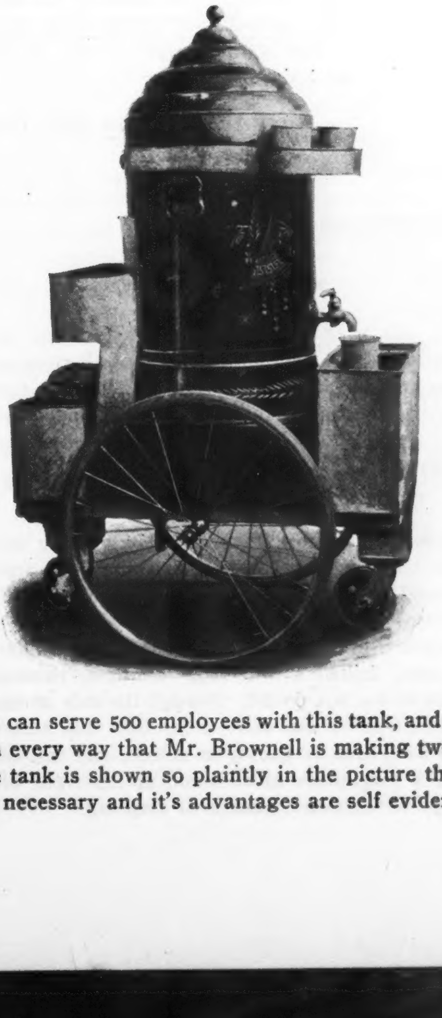
After showing how much better the milling tool is than any other, we may well ask why it has not shown its superiority in all cases. It is simply because it has not been given an equal chance. We are only just learning how to make milling cutters. They have always had, and most of them yet have, too many teeth; so many in fact that it would have been impossible for a chip of decent thickness to get out. Worse than all, the cutting edges have been made without front rake, and they did not cut metal, but scraped it off, so that they would not have cut a decent shaving if there had been less teeth per cutter; and last, but not least, no milling machine has ever been built that would hold the cutters as rigidly to the work as a good modern lathe or planer does.

The milling cutter has a great future, but to show completely what can be done with it, will require a mechanic with a courage equal to his convictions and money enough to back it all up. When such a happy combination is found we may expect to see a milling machine that will astonish every one who compares the results. Such a machine will, of course, have its limitations, and will, in a certain sense, be a special tool, but for work to which it is suited it will be without a rival in any of the present known methods of surfacing metal.

* * *

PERAMBULATING WATER TANK.

The perambulating water tank here shown is used in the factory of F. A. Brownell, Rochester, N. Y., manufacturer of photographic apparatus:



One man can serve 500 employees with this tank, and it is such a success in every way that Mr. Brownell is making two more of them. The tank is shown so plaintly in the picture that no description is necessary and it's advantages are self evident.

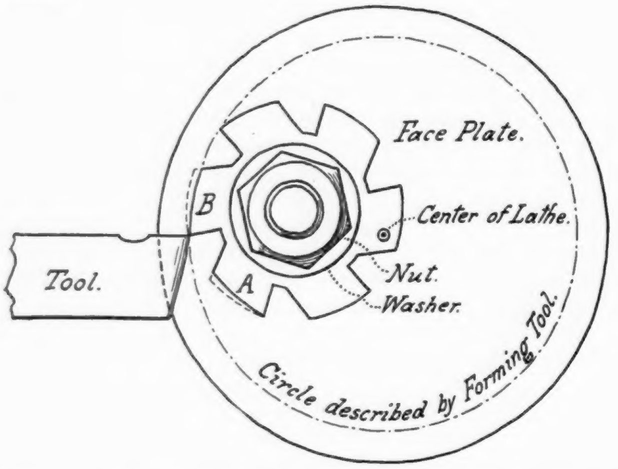
WHAT MECHANICS THINK.

A DEPARTMENT FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE.

Write on one side of the paper only, and when sketches are necessary, send them. No matter how rough the sketches may be, we will see that they are properly reproduced.

RELIEVING MILLING CUTTERS.

While working in a little southern shop about three years ago, the "old man" dreamed that he could make some formed milling cutters he needed. Your humble servant was deputized to do the work, having for his assistance a Lincoln miller and a 12" lathe. The question of relieving the teeth, so that they could be sharpened without change of form, was gotten over as shown in sketch.

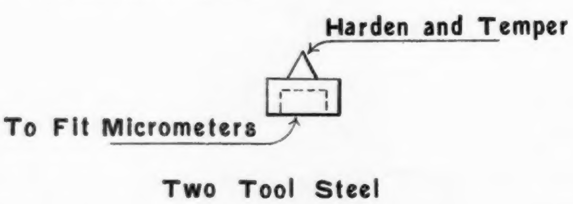


Explanation is deemed unnecessary, as any mechanic will see, in a minute, the principle. Everything must be located about as shown. A and B show two finished teeth, dotted line representing shape before being relieved. It is a good idea to have washer held by a key so cutter won't move when tightening nut after each tooth is set. This method produces cutters—B. & S. make better ones—but the old man was "delighted."

Mercer, Pa. JOHN T. HUME.

ATTACHMENT FOR MICROMETERS.

Tool makers who have a large number of taps to make will find two caps like the drawing to fit on the anvil and spindle of their micrometers very useful. The point of the cap is made the same angle (60°) as a thread tool. With these caps one can make a tap the exact size of the gauge or two or three thousandths larger, just as desired.



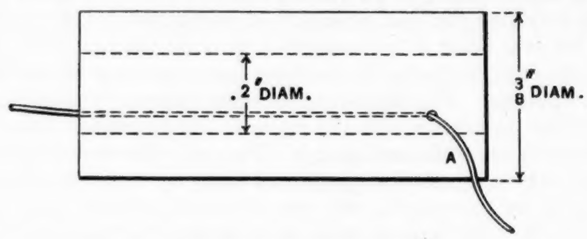
The writer has used something similar to these in the tool room of a large bicycle plant, where taps of all sizes were made. Some had to be larger than the gauge to allow for shrinkage in case hardening. He found this the quickest and most accurate way of any. WIN.

Hagerstown, Md.

WINDING SMALL SPRINGS.

I would like to describe a jig I made for winding coil springs. The other day I had to make about 650 small coil springs .025" in diameter and 4" long of brass wire. The outside diameter of the springs was .200". The coils had to be wound very tight and as I was in a hurry for them I made a piece like sketch of 3/8" round steel, drilled a hole .200" diameter through it, and drilled a hole with a No. 60 drill through the side about 1/4" from one end. The wire A was shoved through this hole and came through the long hole as shown in sketch, and the whole thing slipped over a long piece of drill rod of the right diameter to give the required outside diameter of a spring.

One end of the rod was placed in the chuck of a small speed lathe. The end of the wire was caught in one of the jaws and the lathe started. I used a dog for holding the sleeves and by pulling back on it slightly I had as nicely a wound spring as you would want. The small hole guided the wire and the large



hole prevented the coils from running over each other. I wound them in lengths about 30" long and cut them up afterward. Ran the lathe as fast as it would go and it took but a very short time. The old way of guiding the wire by hand was not in it a little bit with this arrangement. W. W. COWLES.

Torrington, Conn.

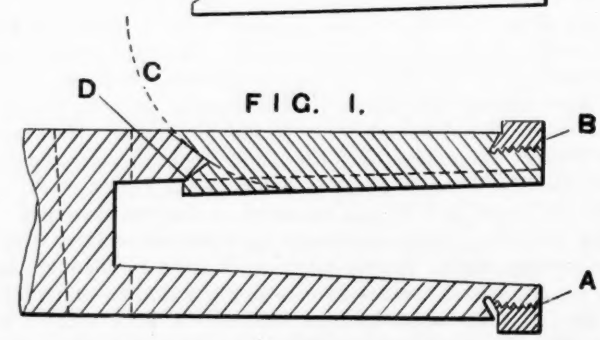
DRILL CHUCKS.

While in charge of a tool room some months ago, there was a great deal of trouble in the shop, caused by the drill press men tearing out or breaking the feather or spline in the drill chucks. All of our drills and rose reamers were taper fits, and depended on the spline to drive them. It was a waste of time to try chipping and filing a dove tail seat for a spline, and get the spline to stay. The idea of trying something else suggested itself to the writer, and with the following result.

I turned down and threaded the end of the chuck, as shown at A. Then fitted on the nut B; after the nut was fitted it was removed and the chuck sent to the milling machine, where, with a narrow cutter a slot was cut through one side of the chuck, as

FIG. 2.

FIG. I.



shown by the dotted lines C. Then using a thin file in the slot I formed the angles D. The spline was then well fitted in the slot and at the angle D. The spline is left long enough to have the nut B screw up tight against the shoulder E, Fig. 2 (which shows the shape of the spline), which holds the spline rigidly in place. The inside face of the nut is turned to fit this shoulder, and the nut B is plain, having no flat sides; being screwed up with an alligator wrench. The drills may break or the shank of the chuck twist off, but the spline "holds the fort." No, it is not patented; use it. W. DE SANNO.

Tulare City, Cal.

KINKS FOR THE LATHE.

A number of machine steel buttons with grooves as in Fig. 2 were cut on the face plate of a lathe by an apprentice. In Fig. 1, a represents the face plate, b, b' wrought iron pieces 1/2" x 1 1/4", ground to a circle as shown, and bolted to the plate by 2 5/8" bolts, c, c'. It will be noticed that the center of the circle of b, b' is a little above the center of button d, so that only a

slight pressure on the set screw E is necessary to hold it in place while being operated on. Fig. 2 shows a finished button with the grooves on each side 1/8" wide x 1-16" deep, not very particular, but by the above process, with an ordinary screw clamp on vees the bed for a stop, the job was done quite accurately and in good time.

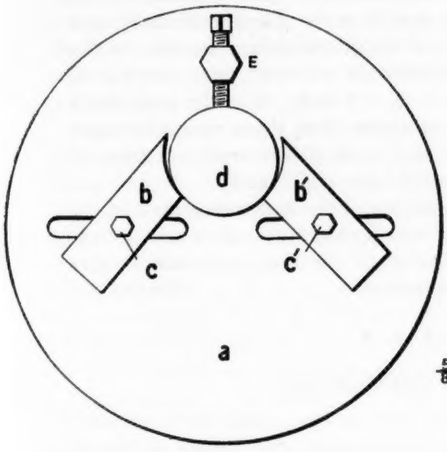


FIG. 1.

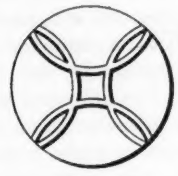


FIG. 2.

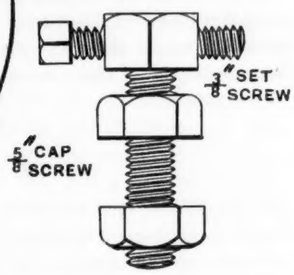


FIG. 3.

Screw E is now a part of the lathe, being very convenient for driving rough forged bolts in facing the heads, which invariably come from the smith shop with one side flattened near the ends.

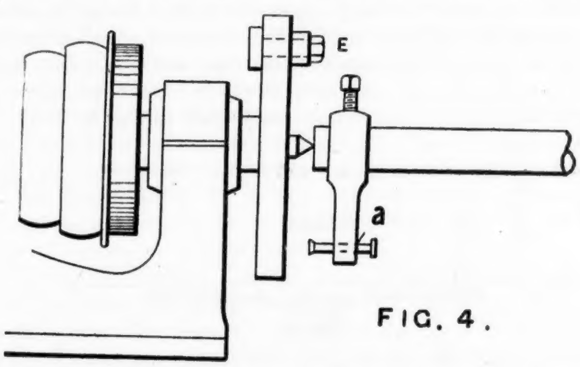


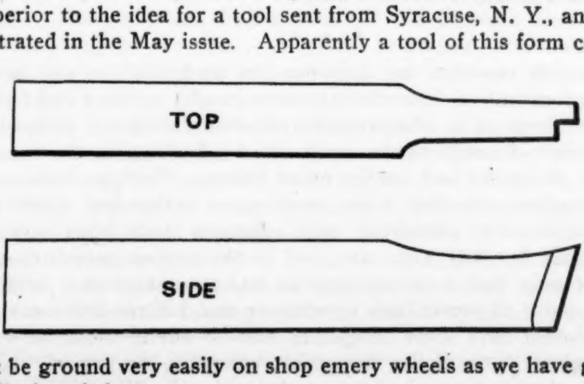
FIG. 4.

Another handy dog for small work can be made by drilling a small hole a, Fig. 4, near the end of a straight tail dog. A wire nail which is a loose fit in the hole is inserted and its end is riveted over so that it cannot fall out. With a bolt in the face plate as at E the work will be driven by pushing in the nail so that the bolt hits against it. The advantage of the arrangement is that by its use the work can be placed between centers or removed, without stopping the lathe and without any danger to the operator. This dog works effectually driving machine steel up to 3/4" diameter, using a nail 3-16" diameter. It has been used several days on filing, the lathe running at the highest speed. G. R.

Louisville, Ky.

ANOTHER CUTTING-OFF TOOL.

We have received another suggestion for a cutting-off tool as shown herewith—this time from Litchfield, Ill. In operation it breaks up the chip into two parts, and the sender thinks it is superior to the idea for a tool sent from Syracuse, N. Y., and illustrated in the May issue. Apparently a tool of this form could

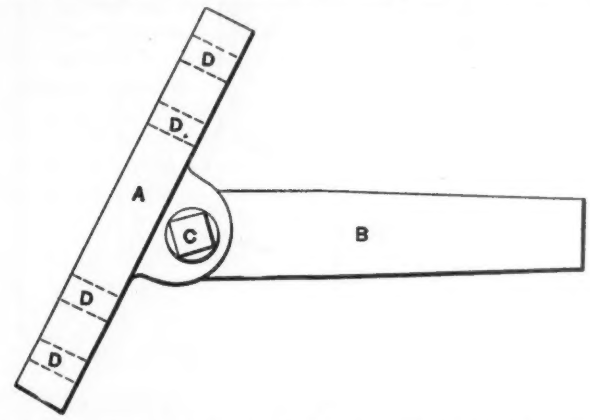


not be ground very easily on shop emery wheels as we have generally found them.

A solution to Mr. Rogers' problem was also sent by the same contributor, but as Mr. Rogers has already furnished a solution it will not be necessary to publish this one. We have also to thank several other readers for solutions.

A HANDY DRILL REST FOR A SMALL LATHE.

The cut shows the device so plainly that it hardly needs any words of explanation. The plate A has ears cast on the back by which it is hinged to the center B, which goes into the tail spin-

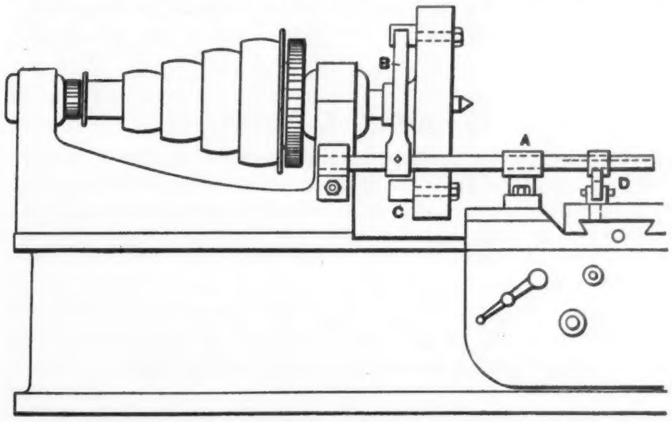


dle of lathe. The plate has a number of holes drilled through it as indicated by the dotted lines D into which pins are placed to hold any piece on an angle into which you wish to drill. The plate is fastened at the desired angle with the cap screw C.

Angelica, N. Y. F. H. Jackson.

A DEVICE FOR RELIEVING TAPS.

I herewith give a description of an attachment for a lathe with a compound rest, which was used successfully in a bolt and nut works, for relieving threads on machine taps which were made in quantities. The lathe carriage was fittted with a bracket marked A in the sketch, forming a bearing for a shaft, the other end of which had a bearing, as shown, on the head stock. The cross-feed screw was removed and one end of the shaft was con-



nected by a crank and link with the cross-slide. The other end of the shaft had the lever, B, keyed to it, and a spiral spring, designed to keep the lever against the rollers, C C. These rollers were on the back of the face plate, there being the same number of rollers as flutes in the taps. As the rollers came in contact with the lever, B, the latter rocked the shaft and moved the slide. The same device may be used for forming cutters on a small scale. J. T. Fink.

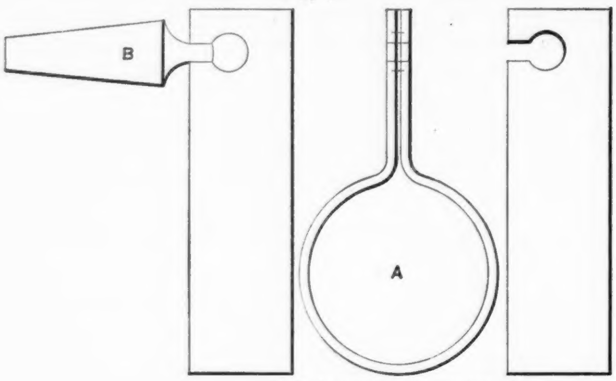
Washington, D. C.

HOW THE OLD BLACKSMITH MADE THE BULLET MOLDS.

The plan of C. F. G (June issue) for making the ball and socket joints was an excellent one for the occasion. I treminds me of the first pair of bullet molds I was proud possessor of. In my youthful gun-trading operation I had come into possession of a sure enough rifle, complete in all its appointments except that there were no bullet molds. To get these I saw no way for it but to send a long way—this happened in the country —to the nearest gunsmith. In my trouble I sought sympathy of the old village blacksmith, never expecting he would be able to help me in any way, although of his willingness there was no room for doubt. I had, at that time, never seen the inside of

a machine shop, or the outside either, and I am rather certain he never had. To my astonishment he told me he had never made such a thing, but he knew he could, and as there was never anything of a driving nature around the little smithery, he forthwith began operations.

First he forged the piece A, and, as it happened in C. F. P.'s case, an old file was the stock. Through the two ends (which



THE OLD BLACKSMITHS JOB

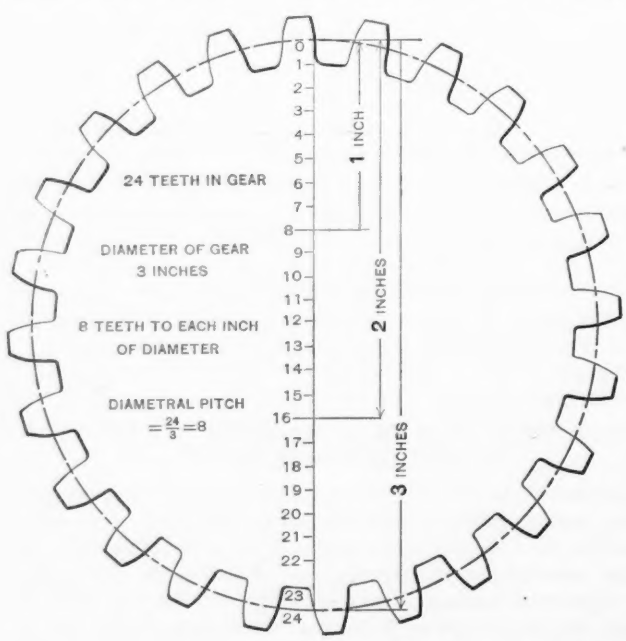
had been smoothly ground before the piece was bent) he drilled a hole, by hand, the diameter of the mold that was to be, and filed the side notches. When this was tempered he had a spring tool for sinking the ball of the tool B. The shank of this tool fitted his bit brace. The ball and stem he filed somewhere near to size, sprung open the ends of A, inserted the end of B, and turned it with the brace. As the size of the ball was decreased the two ends sprung together, and when, with the chips cleaned out, the ends came together the ball was to size. This tool (D) he called a cherry, why, I never knew unless it was because the business end was round and had a stem. Filing teeth around the ball and tempering it completed the tool.

With the two parts of the mold drilled into a little, so as not to leave too much stock to be cut out by the cherry, the parts joined together by a pin and a small hole drilled for the stem, the manner of completing the molds need not be described. The job was not particularly handsome, but it was real good, which was better. H. F.

Keene, N. H.

DIAMETRAL PITCH.

I was interested in the articles upon gearing that appeared in your last issue, and have no doubt they will be of great value to mechanics who are trying to master some of the harder branches of their trade, like that of gearing. There is one simple



question in this connection that I think it might be well to explain for the boys—that of diametral pitch. It always bothers them when they get up to my room, where they have a little experience in gear cutting, and this is the way I make it clear to them. It is clear that the circular pitch of a gear is the distance from one tooth to another, measured on the pitch line, but with diametral pitch it is different—there does not seem to be any measurement about it. This assumption is correct, as it is not a measurement, but a ratio. It is the number of teeth in the gear divided by the diameter. Another definition is the number of teeth to each inch of diameter—and still another, that it is the number of teeth in a gear 1 in. in diameter. All of these definitions amount to the same thing. In the illustration is a 3-inch gear having 24 teeth. The diametral pitch $= 24 \div 3 = 8$. If we let each mark on the diameter stand for one tooth, then there would be eight divisions or eight teeth to each inch of diameter. A gear of 8-pitch, 1 in. in diameter, would have eight teeth.

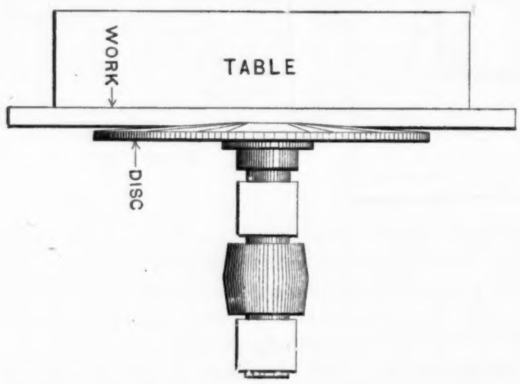
As the diameters of gears come in even measurements and the circumferences in fractional measurements, it is better to express the tooth sizes in relation to the diameter than to give them in terms of the circumference. FOREMAN.

Cincinnati, O.

* * *

FACE GRINDING.

C. H. Besly & Company, of Chicago, make face grinders that are capable of finishing many pieces that would ordinarily is done on the shaper or milling machine and polished by hand. These grinders consist of a flat metal disk on which emery cloth is fastened, and the work is supported by a rest and moved back and forth against the face of the wheel. With short pieces of work such a grinder will produce nice, true surfaces, and clean edges. With long pieces, however, it will not work so well. In such cases the piece being polished bears against the full face of the disk, one-half of which tends to hold the piece down against the rest, and the other half, moving upward in the opposite direction, tends to raise it. Under such conditions, of course, good work cannot be done.



There is a very simple remedy for the trouble, however, which the writer saw at Jones & Lamson's at Springfield, Vt., and which is shown in the accompanying sketch. The disk, instead of having a perfectly flat face, was faced off slightly crowning, or cone-shaped, and the rest, which is a little below the center of the disk, was tipped slightly so as to be at right angles with the face of the wheel. Long pieces of work would then bear only at the central part of the disk where that motion is all one way and would not touch at the edges at all. The taper of the disk is much exaggerated in the cut, but it illustrates the principle more clearly because of this.

* * *

"The best remedies for corrosion are generally the simplest and least expensive; but, after all, there can be no hard and fast rule laid down as to what should and what should not be used, as so much depends on the water, the kind of boiler, the conditions of work, and many other things. Perhaps two of the simplest remedies ever used as a safeguard against incrustation are petroleum and common soda; but even these must be used with care, and in the proper proportions, else the evils that they cure may be less than those they bring about; and it all comes back to what we said before—that steam-users should have some competent man to advise them, be he the engineer to a boiler inspection company, or anyone else capable of giving sound advice on the subject."—"Engineering."

HIGH CARBON VS. LOW CARBON STEELS.*

The subject of the relative endurance under reversed stresses of materials of different tensile strength and hardness, has recently been attracting a considerable amount of attention from engineers, and the theory, until recently universally held, that for withstanding these repeated or reversed stresses a very soft material was necessary, has had to be revised to the extent of complete abandonment, at least in many cases. It is not with the idea of commencing anything new, but merely as a strictly practical confirmation of the valuable work done by others that the following data are given.

About six years ago the company, with which the writer is connected, bought a compound locomotive of the Baldwin or Vauclain type, no description of which is needed before this Society, except to recall, for the sake of clearness, the fact that the high and low pressure cylinders lie as close together as possible, one vertically above the other, the rods from the two cylinders being fastened to the same crosshead, which is of the four-bar type, and located centrally between the two rods. The wings or guiding surfaces are made very long in the direction of the stroke, to overcome the torque set up by the unequal and constantly varying pressures on the high and low pressure pistons respectfully. These pressures are made as nearly equal as possible by the steam-distribution, but practically there is always considerable difference at some part of the stroke, so that there is a stress tending to tilt the crosshead one way during one stroke and the opposite way during the other. This stress, occurring while the crosshead is undergoing its regular reciprocating motion, puts a considerable pressure on the diagonally opposite corners of the guiding wings, and, the reciprocating motion going on while under this pressure, wear takes place on the corner of the wings first, and allows a slight rocking of the cross-head, a complete oscillation occurring at each revolution when running under steam.

The piston-rods are fastened to the crosshead with the regular taper fit drawn up to a shoulder by a nut. This connection being rigid, and the opposite end of the rods prevented from vibrating with the crosshead by the fit of the pistons in the cylinder, the rods are bent at the shoulder through a very small arc in each direction vertically, at each revolution.

This first locomotive ran for three years and two months, when a duplicate was bought, and the first put in the shop for a general overhauling previous to taking the place of the smaller engines on another part of the road, the new one taking the run of the old one. During the overhauling the piston rods were renewed, having worn down too small to work well with the metallic packing any longer. The material for the new rods was ordinary "machinery steel," taken from stock on hand. The rods on this engine (No. 4), it should be stated, were straight from shoulder to shoulder, while those of the "duplicate" (No. 5) were reduced in the body, having a collar ¼ inch larger than the rod and ½ inch wide to the shoulder at the crosshead end.

After having been in service about fourteen months, one of the low pressure rods of No. 5 "let go," and smashed the cylinder head, without, however, doing any serious damage. Within a few weeks the overhauled engine did the same thing.

This was becoming a serious matter, and after some careful consideration the writer ordered some genuine Swedish iron to make rods of. It was beautiful stock, and so soft that it acted almost like lead in the lathe, being very difficult to get a smooth finish on. A set of these was put into one of the engines at once, and ran about four months, when one of them let go in the same way. The rods that broke were all low-pressure ones, due undoubtedly to the fact that in the "emergency," or starting gear, those cylinders get almost full boiler pressure, 180 pounds per square inch. The rods were all broken in the same way, and right in the shoulder, the metal cracked at top and bottom, and the crack gradually widened, as could be seen by the worn appearance of the upper and lower segments of the break, which gradually approached each other until only a narrow horizontal strip of solid metal was left across the middle of the rod when the final rupture occurred.

Soon after ordering the Swedish iron, the writer came across one or two articles bearing upon this subject of the endurance of soft and hard steel or iron under fatigue, and describing tests made to elucidate this point, notably those of the Pope Tube Company and the Bethlehem Iron Company, which showed quite clearly that high-carbon steel was infinitely better than low-carbon, and that nickel-steel was better than either for such service; also that very soft material, like Swedish iron, lacked endurance under fatigue.

Therefore the breaking of the rod of this material was not a very great surprise, and was met by ordering material for a set of rods of high-carbon and one of nickel-steel from the Bethlehem Iron Company. These have now been in considerably over a year, and we hope that they will last long enough to wear out without breaking.

The writer had the three rods which had broken, and the one which had worn out, analyzed, to see how they bore out the theory of high-carbon material versus low.

The results are given herewith:

	Sulphur.	Manganese.	Phosphorus.	Silicon.	Carbon.
First rod in No. 4 locomotive; machine steel; ran three yrs. and two mos. without breaking..........	.094	.70	.082	.014	.466
Second rod in No. 4 locomotive; machine steel from Longdale stock; ran fifteen months and broke.........	.056	.64	.125	.021	.152
First rod in No. 5 locomotive; iron; ran fourteen months and broke........	.020	.12	.04	.148	.129
Third rod in No. 4 locomotive; Norway iron; ran four months and broke...	.006	.05	.055	.021	.044

It will be seen that these results bear out the theory to a striking extent, there being nothing in No. 1 to cause its far greater endurance except the carbon, and possibly to a slight extent the sulphur, which is also claimed by some to be a hardener.

It is very difficult to deduce any quantitative results as to number of reversals of stress producing flexure even approximately, because even given the approximate daily mileage of the engines and the size of the drivers, it is impossible to say what portion of the total running was done under steam, the grades being quite heavy, and the trains running by gravity for nearly half the total distance.

If thirty miles per day under steam, twenty-eight days per month, be taken, the diameters of the drivers being thirty-six inches, the revolutions per day would be, say 16,000, and per month say 450,000; this would make for the second and third rods about 6,000,000 double flexures before rupture, and for the Swedish iron rod say 1,800,000.

There is no way of giving the amount of flexure; the crosshead probably never tilted more than 3-64 inch in twenty-four inches to either side of the vertical, but this amount varied as the wear occurred, and was taken up; also it is not possible to tell what portion of the total length of the rod absorbed this flexure, so that it is impossible to give any figures having scientific value.

The theory of the superior endurance of harder materials under fatigue has been explained many times, and by those far more competent to do it than the writer, so that nothing on that subject is said here.

* * *

BRASS.

Mr. Editor: I inclose an item from a daily paper which is part of a letter written by a person who is said "to know Spain intimately." It may interest the brass workers.

"Some of our hasty countrymen say flippantly that Spain is 'played out.' Never were they more mistaken. The country is still there, as strong by nature as ever, with resources unexhausted and almost untouched. If France is richer in soil, Spain is richer in mineral wealth, and, indeed, is said to be the richest country in Europe. It is overrunning with natural wealth; *its hills bring forth brass* and its mountains iron, while its magnificent coast line opens its broad-armed ports to invite the commerce of the world."

This letter confirms an opinion that I have held for some time. The trouble with Spain is that she has too much brass. All the Dons have to do is to go out and dig it and temper it for swords or put it in a forming lathe and turn out 12-inch guns. Dead easy.

S. PAIN.

* From a paper read before the American Society of Mechanical Engineers, by J. E. Johnson.

MORE ABOUT GEARING

FOR YOUNG MECHANICS—THIS TIME ABOUT BEVEL GEARS.

RETSEL.

Before leaving the subject of gearing, it may be of interest to some of the younger readers if a few words are said about bevel gears. It will not be my purpose to give directions for laying out such gears, but, rather, to explain two or three theoretical points about them that are not often clearly stated.

In the last number we saw that spur gear teeth are designed to transmit motion like that of two wheels or disks rolling in close frictional contact, and that these disks, when considered in connection with the gears, are called pitch cylinders.

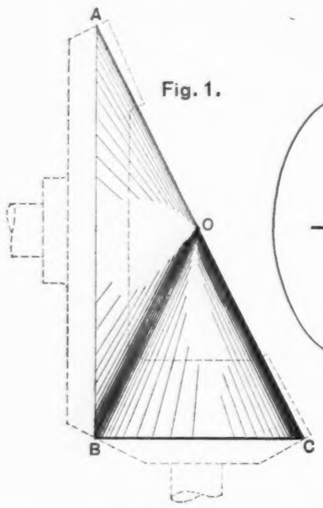


Fig. 1.

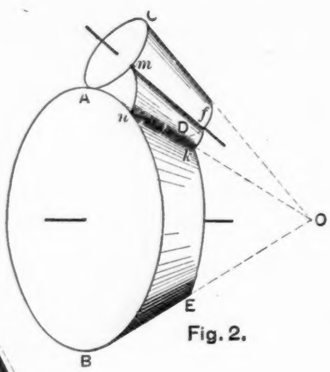


Fig. 2.

When a drawing of a gear wheel is made, a circle, called the pitch circle, is drawn to represent the pitch cylinder. In like manner the tooth curves represent curved surfaces at right angles or perpendicular to the paper, and in the case of the cycloidal system these surfaces are generated by small cylinders or disks rolling upon the pitch cylinder. In the case of the involute system, where the curves are generated by a cord unwinding from a circle, the surfaces themselves are generated by a ribbon or band unwinding from a cylinder. Coming to bevel gearing, instead of pitch cylinders we have pitch cones which, when in rolling contact, have their points or apexes at a common point, as shown in Fig. 1. In this figure O A B and

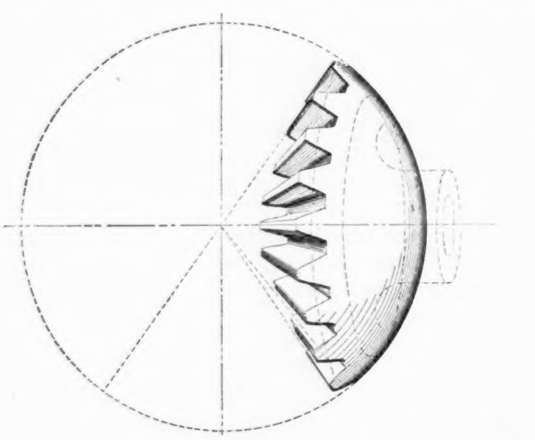


FIG 3.

O B C are two pitch cones having their common apexes at O and the dotted lines show how two gears would be formed on these cones.

The tooth surfaces of a bevel gear, therefore, would be generated in the case of the cycloidal system by a small cone rolling upon the pitch cone, and in the case of the involute system by a band unwrapping from a cone; the only difference between the spur and bevel gear being that in one cylinders form the basis of the teeth, and in the other cones are used for the purpose.

In Fig. 2 is shown how the tooth surfaces are actually generated. Let A O B represent the pitch cone of a gear, the part A B E D being the pitch surface of the gear itself. Let A O C represent a smaller cone rolling upon the larger one, and serving as a generating cone for rolling up the tooth surface. Point m will generate the curve n m, and point f the curve k f. The whole tooth surface generated will be m n k f.

So far this is very plain, and is not particularly different from spur gearing, as described in the June issue, except that, as stated above, we are now dealing with cones instead of cylinders. But there is one point about bevel gearing that may not be so clear. Looking at Fig. 2, it will be seen that point m, as it sweeps up the curve n m. will pass over the surface of a sphere, or ball, whose center is at O. In other words, the curve m n lies on the surface of a sphere instead of on a flat plane like a sheet of paper. Study a minute and you will see why this is so. Suppose, for example, you have a stick, one end of which is at m and the other end is pivoted at O. However you move the end m of the stick, it will describe the arc of a circle about O, and will therefore always lie somewhere in the surface of a sphere having its center at O.

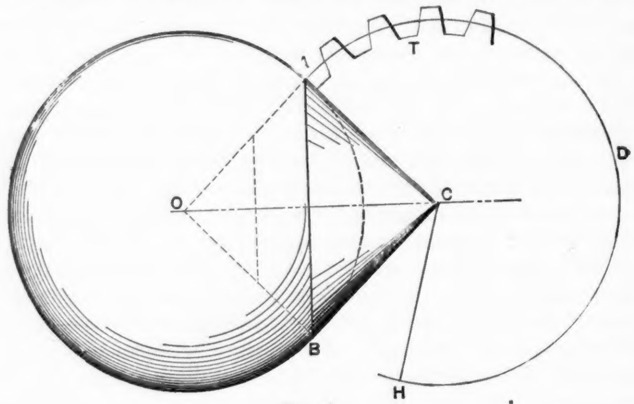


Fig. 4.

By similar reasoning, also, it can be shown that the involute curve will lie on the surface of a sphere. To be theoretically correct, therefore, bevel gear tooth curves should be traced on the surface of a sphere as shown in Fig. 3, instead of on a flat surface, the center of the sphere being at the apex of the pitch cone. Of course this method is not a practical one for laying out gear teeth, and an approximate method, called "Tredgold's Approximation," which is just as good for practical purposes, is always used.

By this method the tooth curves are drawn on a cone, which is tangent to the sphere at the pitch line of the gear, as in Fig. 4, where A O B is the pitch cone and A C B is the other cone on which the curves are laid out. In order to get at this surface so as to draw the curves with the compasses, the process is simply to unwrap or develop the surface of the cone. The

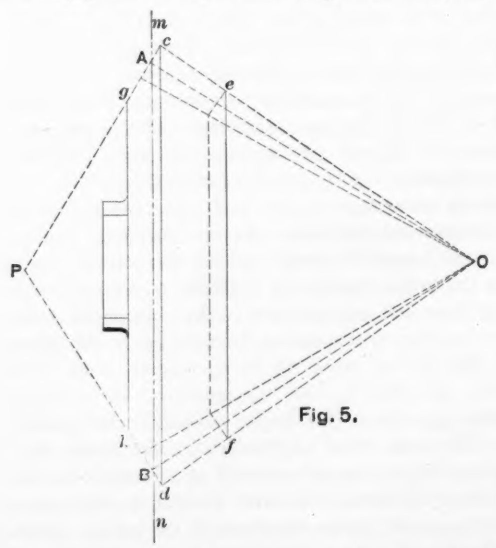


Fig. 5.

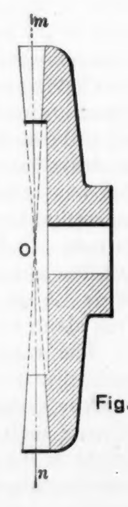


Fig. 6.

unwrapped surface is represented by A D H in the figure. The length of the arc A D H is equal to the length of the pitch circle A B, and the teeth are then drawn upon the unwrapped surface just as for spur gears of the same dimensions. This is the method used by a pattern maker in shaping the teeth of a bevel gear pattern. The drawing comes to him with the teeth laid out as at T in Fig. 4. He makes a templet from one

of the teeth and then this templet is held against the back face of the gear and the tooth marked off.

Teeth laid out by Tredgold's method will vary only slightly from the true spherical tooth and the actual error is even less than this; for although the curves may not agree exactly with those laid out on the sphere, they will be of such a shape that they will transmit a practically perfect motion. Bevel gear generating machines are now made which generate perfect tooth curves without any laying out whatever. Some of these were illustrated in the last number of the paper.

To bring what has gone before down to a more practical basis, I have made a sketch in Fig. 5 of a bevel gear blank. The pitch line is m n and A O B is the pitch cone. The outer surface c d e f of the blank is conical and converges or points toward O. The back face c g h d converges toward P, and the lines A P and B P, which form what may be called the back

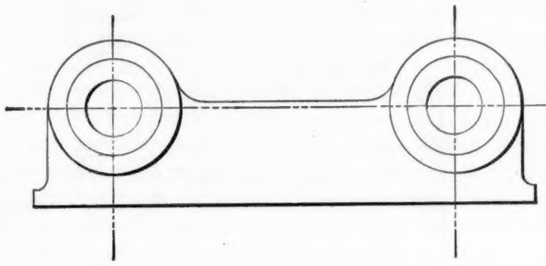
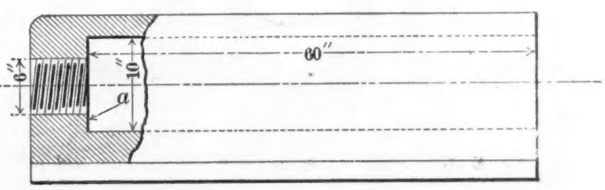



Fig. 1

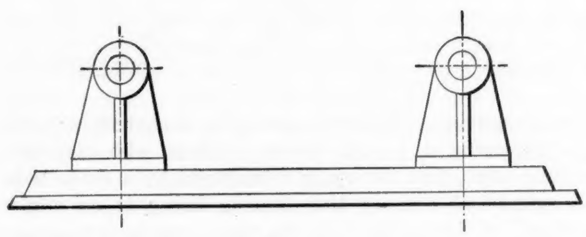
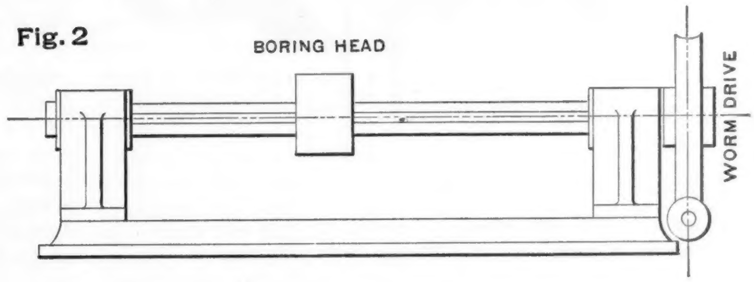



Fig. 2

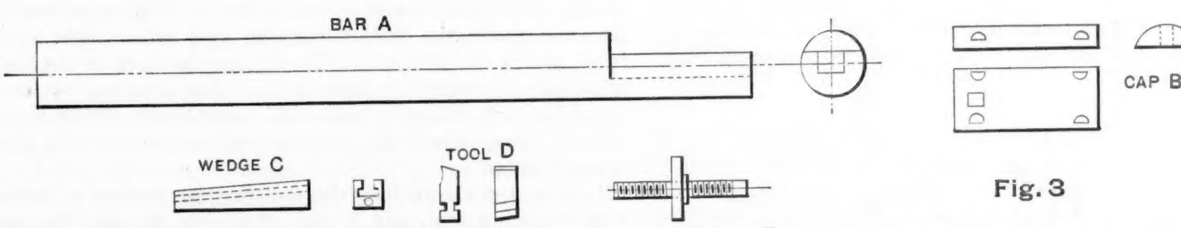


Fig. 3

cone, are at right angles to the lines A O and B O; but it will be seen that c g and c e are not at right angles.

Sometimes it is asked whether there is such a thing as a bevel gear rack. No, there is not, in the sense in which we understand the term, but in Fig. 6 is shown what corresponds to the rack of the spur gear. It is known as a crown gear. The pitch line is m n and the apex of the pitch cone falls on this line at O. The pitch cone, therefore, has no height; in other words, the cone takes the form of a disk and there is no cone there. These gears are, in fact, generally called disk gears, and they have to answer for the rack in bevel gearing.

* * *

A MACHINE FOR FINISHING CYLINDERS.

J. H. Francis.

Having occasion some time ago to bore several large cylinders, as shown in Fig. 1, and not having any tools suitable for the job, it became necessary to make as cheap a machine as possible to do this particular work, and the one shown in Fig. 2 was made. It consists of a baseplate with four pedestals for bearings for the boring bars, which are similar to the ordinary boring bars used for boring cylinders.

No great pains were taken with the bars nor the bearings, and in order to have the cylinders perfectly cylindrical and parallel, which they had to be within .003 of an inch, a large reamer was substituted for the boring head to take the finishing cut. By this means a satisfactory job was made.

The end of the cylinder at *a*, Fig. 1, had to be faced. This was done with the contrivance shown in Fig. 3; the bar *a* has one end flatted as shown; *b* is a cap fitting on the flatted end and held in place with screws; in the slot in the end of the bar, the wedge *c* is fitted, and the tool *d* fits in the square shown in cap *b*; the flange

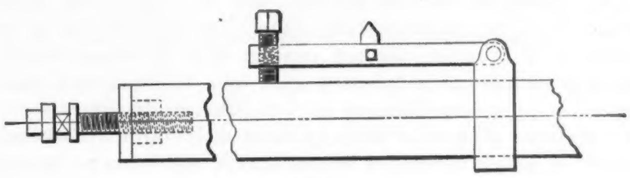


Fig. 4

e with screw is fastened to the end of the bar. In operating, the screw moves the wedge lengthwise of the bar, and by this means the tool is fed in or out, as desired.

For cutting the thread in the end of cylinders a device shown in Fig. 4 was used, which consists of a tool-bar pivoted at one end with a thread tool in the center and an adjusting screw at the other end. The screw shown in the end of the bar is of the same pitch as the thread to be cut in the cylinder. This screw is held stationary and the bar in turning moves forward at each revolution a distance equal to the pitch of the thread. After a cut is taken the tool is drawn in and the bar brought back to the starting point. The worm gear for this device is secured to a sleeve that the bar slides through.

* * *

Dr. Charles E. Emery, one of America's best-known engineers, died at Brooklyn, N. Y., on June 1, at the age of 60 years. During the early years of his life he devoted his time to the study of mechanical subjects, practical mechanical work in the shop, and later to the study of law, with a view to becoming a patent lawyer. During the civil war he was an assistant engineer in the navy, and since then has been at times more or less closely identified with naval and other government work of both an experimental and constructive nature. Some of these tests, which have been published, other tests in connection with the Institute Fair in New York and similar work at the Centennial, gave him a justly earned reputation in this branch of engineering. One of his greatest undertakings was the designing of the plant of the New York Steam Company, which, at its completion, represented an expenditure of $2,000,000. He has conducted a large consulting business during the past ten years.

VARIABLE SPEED COUNTERSHAFT.

A variable speed countershaft has recently been brought out by the Reeves Pulley Co., Columbus, Ind., a general view of which appears in Fig. 1.

The distinctive features are two sets of cone disks spline mounted on two parallel shafts. One disk of each set is attached to a common pivoted straight bar, as shown clearly in Fig. 2, which bar is operated upon by a screw in such manner as to bring together one set of disks as the other set is forced apart. The inner sides of these disks form a V-shaped groove in which is fitted a belt of special construction having its tractional bearing on the edges instead of the bottom, as in an ordinary belt.

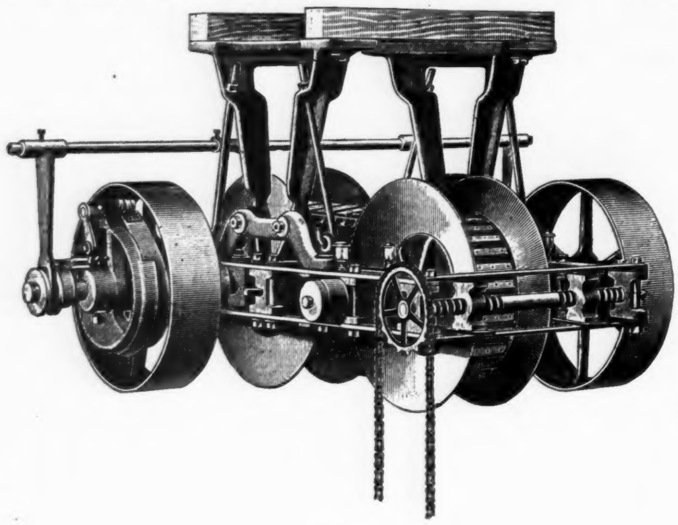
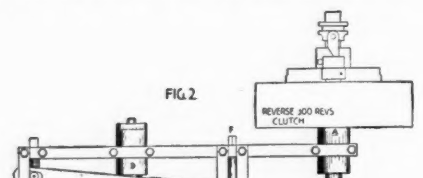


FIG. 1.

The operation is very simple. One set of disks acts as driver, the other as driven. As the driving circumference of one is increased, the other is decreased; the power is transmitted and the variation anything within the compass of the two extremes.

Ball bearings are employed where possible and every precaution is taken in the construction of the countershaft to bring the loss of power down to the minimum. The belt is composed of a series of leather and iron strips riveted onto a rawhide base.



This gives a powerful bearing on the edge, and it is claimed it will run for years without kinking or getting out of shape. A screw take-up is provided in case the belt needs tightening.

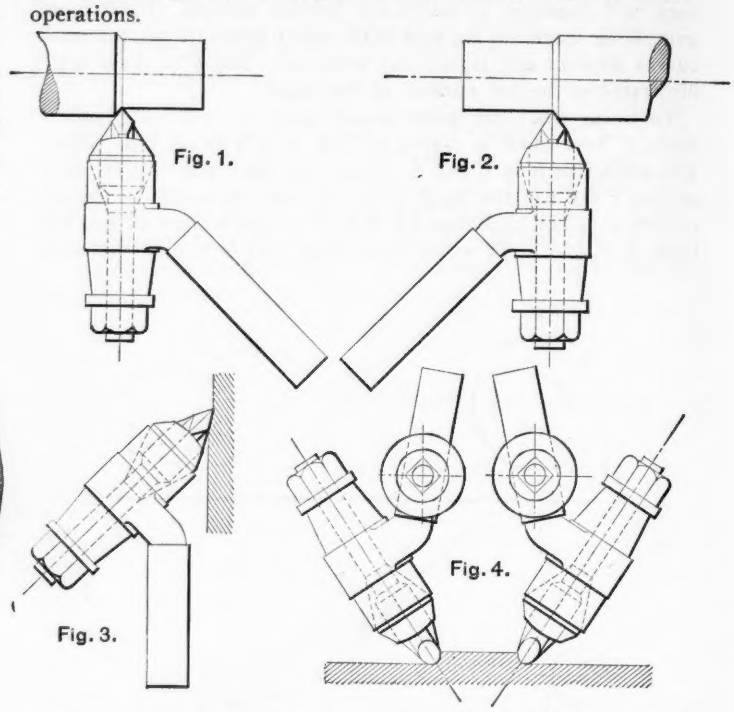
Aside from its use for ordinary purposes in shop or factory the makers believe the device will find a field in motocycle work. Three motocycles have already been constructed with this drive, two of which have been tested very thoroughly and have given satisfaction.

* * *

Just why locomotives are like women and are called "she" is thus explained by an exchange: "They wear a jacket, an apron, have shoes, hose, and drag a train behind them; they have a lap, need guides, ride wheels, will not turn out for pedestrians, sometimes foam and refuse to work; they attract the men, sometimes act very contrary, and it always takes a man to manage them."

THE SELDIS TOOL HOLDER.

In the last issue, in the description of the new tool holder which is now being put on the market by Oscar Seldis, 15 Follen street, Boston, Mass., we omitted to point out its feature of universality as a tool for various kinds of lathe and planer work, making but one style of holder necessary for most operations.



As the construction of the holder was fully described, we will simply say regarding it, for the benefit of those who may not have the June issue, that the cutter is clamped by a draw bolt against a cylindrical bearing, this bearing being at an angle with the shank of the holder, and the piece against which the cutter bears being cone shaped to secure rigidity. These details are clearly shown in the accompanying sketches, and it will be evident from Figs. 1 and 2 that besides serving as an ordinary diamond point, the holder may be used either right or left hand and as an offset tool. To change the hand of the holder it is only necessary to turn it the other side up, rotate the clamping bolt and cone piece half around, and put in another cutter if more rake is desired than can be obtained with a flat-ground cutter.

In Fig. 3 is shown how the tool may be used as a left-hand side or facing tool, and it can, of course, be used for right-hand facing by changing as above described. In Fig. 4 it is arranged for planer work with a cutter of round steel inserted.

* *

We submit the following without criticism. The best way to find whether or not it will work is to try it.

A simple and effective way of cleaning rusted iron articles consists in attaching a piece of ordinary zinc to the articles and then letting them lie in water to which a little sulphuric acid is added. They should be left immersed for several days, or a week, until the rust has entirely disappeared, the time depending upon how deeply they are rusted. If there is much rust a little sulphuric acid should be added occasionally. The essential part of the process is that the zinc must be in good electrical contact with the iron; a good way is to twist an iron wire tightly around the object and connect this with the zinc, for which a remnant of a battery zinc is suitable, as it has a binding post. Besides the simplicity of this process it has the great advantage that the iron itself is not attacked in the least as long as the zinc is in good electrical contact with it. When there is only a little rust, a galvanized iron wire wrapped around the object will take the place of the zinc, provided the acid is not too strong. The articles will come out a dark gray or black color, and should then be washed thoroughly and oiled. The method is specially applicable to objects with sharp corners or edges, or to files or other articles on which buffing wheels ought not to be used. The rusted iron and the zinc make a short circuited battery, the action of which reduces the rust back to iron, this action continuing as long as any rust is left.—The Engineer.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

97. G. L. A. writes: I should like to get some information about balancing a small upright engine. 1. Should the connecting rod and eccentric rods be removed when the revolving parts are balanced? 2. Does the whole weight of the connecting rod revolve with the shaft, or only part of it? 3. Can a difference in lead or compression be made to counteract the weight of piston, etc.? A. In a vertical engine there are three resultant forces at work that it would be desirable to balance. First, there is the vertical throw of the piston, piston rod, cross-head and connecting rod, tending alternately to raise the engine from its foundation and to push down upon the same; second, there is the horizontal throw of the connecting rod tending to either slide the engine on its foundation or to cause it to vibrate; and third, there are the crank, eccentrics, etc., which cause the shaft to run out of balance. The only one of these three that a revolving counterweight can perfectly balance is the last one. It can, however, be made to balance the reciprocating parts (that is, the piston rod, cross-head and connecting rod) nearly enough, so that with a good foundation the engine will run quietly. Generally the foundation and engine frame are heavy enough to take up the vertical throw, and hence the side throw of the connecting rod and the rotating parts are all that need be considered. It will be seen that if it were attempted to completely balance the vertical throw, the side throw would probably be overbalanced, and it might even be possible to overdo it, so that the engine would not run as well as before. On the other hand, if the side throw were balanced, the vertical throw would be partially balanced, and the foundation should take care of the rest. In case the engine is running on an upper floor, this result can be effected by setting it on a heavy casting or a block of stone. Now answering your questions directly: 1. We see no advantage in removing the connecting rod and should pay no attention to the eccentric rods. On a small engine balancing must be a matter of experiment. We should connect up the parts and try different weights until we got them right. 2. If you weigh crank and cross-head ends of the connecting rod separately, by resting each on the scales and supporting the other end at the same time, you obtain the weights that go with the crank and cross-head, respectively. But this will not help you, since the effect of the former weight is not at the crank pin, but must be considered as acting, or as being concentrated, at a point further up the rod, which is difficult to determine. We should not advise you to attempt any calculations of the sort on a small engine, as we believe they would be of no value whatever. 3. It is quite common to give a little more lead at the lower end of the cylinder for this purpose, and with good results.

98. A reader writes: Inclosed please find an indicator card taken from a 14x30x24 vacuum pump, which is working an independent condenser placed about 250 feet from engine. The pump is working about 42 strokes per minute; a 40-pound spring is used and maintains about 25 to 27 inches vacuum. The pump exhausts into condenser. Please say what you think about it. It seems to be giving satisfaction. A. We do not see any reason for commending the card, but rather the contrary, for which there may be causes that we know nothing about. The data you give are insufficient to form any opinion from. For that purpose full data of engine should be given with card from engine cylinder and steam and pump cylinders, each marked with dimensions. Size of pipes and valves should also be given; 3½ inches is long enough for the diagrams. The drum motion should be quite correct and boiler pressure, together with temperature of water, should be given. It would be quite unfair to give an opinion without knowing full particulars.

99. P. C. R. has a hydraulic pump that works against a pressure of 2½ tons per square inch. The pump has three plungers, one 2 inches and two 1 inch diameter. When a pressure of ½ ton has been reached the 2-inch plunger is thrown out of action. This is now done by opening a small pet-cock at the proper time. He asks: Can I not accomplish this automatically, and how? A. One way of doing this would be to make a small cylinder, which need be nothing more than a round piece of metal, say 6 inches long, with a straight, smooth hole through it. To this fit a plunger, very accurately. To avoid rusting the cylinder and plunger may be made of hard bronze. The top of the cylinder may be open, the plunger extending up through it and being loaded to hold it down until a pressure of ½ ton is reached. Thus (we assume you to refer to gross tons, 2,240 pounds) suppose the plunger to be 7-16 inch in diameter; the area of a 7-16-inch circle is .15 inch. The load on spindle will be 2,240 ÷ 2 × .15 = 168 pounds. When a pressure of ½ ton is reached it will raise the plunger, and in rising the plunger can be made to open the pet-cock, which can be located in a pipe extended for convenience. In a variety of ways that will suggest themselves, as a band around a small wheel, or a rack and pinion, the plunger can be connected to the cock so as to open it and a weight can be arranged to close it, or the weight on the plunger can do it, according to construction. If the plunger is inclined to go too high or too far, it can be checked by a rubber buffer. If the work is well done, and the plunger finely fitted, it will scracely require packing, although it can be arranged for packing if thought best. A slide to uncover a small port can be employed instead of the cock, if thought better; variations in details will readily suggest themselves.

100. Q. L. writes: I have trouble in setting the tailstock of a lathe over just right for turning the taper I want. Sometimes—generally—the piece turned is not a straight taper as I find by trial. Can you help me in any way? A. Two things are to be observed in turning a taper when the tail stock is set over to get the desired taper. One is to set the tail center over the proper distance, and the other to use a tool the cutting point of which stands at the same height from the ways as the lathe centers. In Fig. 1 the lathe centers are represented as set to hold a piece for

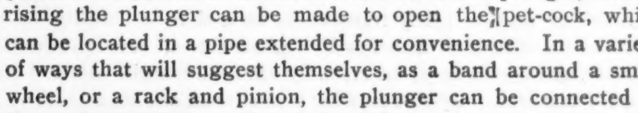


FIG. 1.

turning straight. The piece is a little more than 24 inches in length; so much more that the points of the centers are just 24¼ inches apart when the piece to be turned is between them. It is desired to turn a taper on one end of this piece, the taper to be 5-16 inch in a length of 4⅞ inches. If the centers stood 4⅞ inches apart we should manifestly set the tail centers over one-half the taper to be turned, viz., 5-32 inch. As it is, we must set it over more than this, as much more as 24¼ is greater than 4⅞. Putting this in the form of proportion, reducing the vulgar fractions

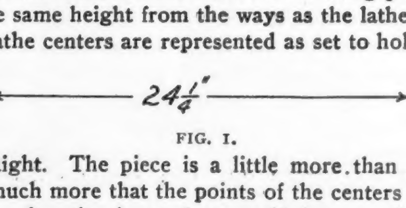


FIG. 2.

to decimals for convenience, we have 4.875: 24.25 :: .1562: .7769 inch—very nearly 25-32 inch—that the tail center must be set over. As to setting the cutting point of the tool at the same height as the lathe centers, you will readily see that you cannot turn a regular taper with the tool set below or above this position by reflecting that you cannot cut (divide) a cone parallel to its axis on any line except on a line coincident with the axis and have the outline of the cut a straight line. Thus if in Fig 2 the cut is on the line *a b*, the outline of the cut will be a straight line. If cut on the line *c d* it is plain that it will not be straight.

101. J. W. asks: 1. What quantity of air is required to be furnished to a cupola for melting iron. The cupola I propose to use is to be about 31 inches inside diameter, and I want to melt from two tons to four tons of iron per day? A. The quantity of air required to melt a definite quantity of iron is primarily dependent upon the quantity of fuel required to do the melting, which in turn depends upon the construction of the cupola and

the way it is handled. Assume that a pound of coal will melt seven pounds of iron, which it should do; then to melt 10,000 pounds, $10,000 \times 20 = 200,000$ pounds of air will be required. About 13 cubic feet of air will weigh one pound; $200,000 \times 13 = 2,600,000$ cubic feet of air will be required for melting five tons of iron. 2. What shall be the number and size of tuyeres and the size of pipe from the fan? A. We have seen good results from such cupolas having three tuyeres, each 2 x 10 in., blast pipe 9 in. in diameter. There is nothing very definite about this. Some would use larger tuyeres and blast pipe, others smaller. 3. What is the wind pressure commonly employed in foundry cupolas? A. This varies all the way from ½ pound, or less, to 2½ pounds. When practicable it is advisable to have the arrangement such that the pressure can be readily varied, starting with a low pressure and gradually increasing to bring about desired results.

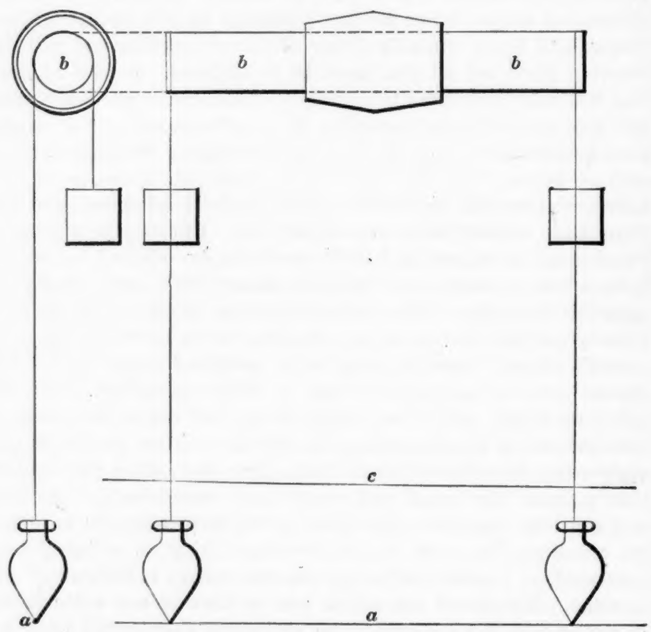
102. J. B. asks: Is it possible to run a 4-inch shaft at 2,000 revolutions per minute, transmitting 1,200 horse-power, and of what material should shaft and boxes be, and how long should the bearings be? A. A rule much used for determining the horse-power that may be safely transmitted by a shaft is: Multiply the cube of the diameter in inches by the number of revolutions per minute, and divide by 94 for steel, by 190 for wrought iron and by 290 for cast iron. By this rule for a steel shaft we have

$$\frac{4^3 \times 2000}{94} = 1,361 +.$$

The shaft would be of ample size. We have no record of a shaft of this diameter running at such a speed and doubt the practicability of doing so. If we felt constrained to run a 4-inch shaft at the speed named, we should make the shaft of crucible steel and line the boxes with genuine babbitt metal. The journals should be accurately ground and we should make the boxes no more than 2 diameters in length. We should by no means be certain of success.

103. W. J. T. asks: Kindly tell me why the lathes having chain feeds are not preferred to those having belts. That is, where the chains connect the feed spindle, or shaft, with the main spindle. Seems to me that the chain is more direct? A. Chain feed such as you refer to may be preferred by some. Others will claim that it is not so convenient to change from coarse to fine feed, or vice versa, when chain is used as when a belt is employed, and that with proper feed pulleys and belt the feed is steady, and regular enough for all practical purposes. 2. Please give a good formula for compound gearing. A. We suppose you to mean compound gearing for screw-cutting. To understand this, first consider the principle involved in simple gearing for the same purpose. That is, the pitch of the lead screw must bear the same relation to the pitch to be cut that the number of teeth on the spindle bears to the number of teeth on the gear on the lead screw. Suppose the lead screw has 6 threads per inch—6 pitch—and the pitch to be cut is 20, we could cut that pitch with a thirty gear on the spindle and a 100 gear on the lead screw, because $6 \times 3\ 1\text{-}3 = 20$ and $30 \times 3\ 1\text{-}3 = 100$. We may put this another way, which amounts to the same, by saying that the pitch of the lead screw multiplied by the number of teeth on the gear on that screw must equal the pitch to be cut, multiplied by the number of teeth on the gear on the spindle. Thus, in this case, $6 \times 100 = 600$, and $20 \times 30 = 600$. From the foregoing it may be readily seen that if we multiply the pitch of the lead screw and the pitch to be cut by the same number (whole number or fraction) we shall have the gears for spindle and lead screw respectively. Thus suppose we had selected the number 4 for a multiplier. Then $6 \times 4 = 24$ for the spindle and $20 \times 4 = 80$ for the lead screw, which would cut the same pitch as 30 and 100. The principle is the same in compound gearing, there being only an increase of combination. Thus in simple gearing there is one driving gear, that on the spindle, while in compound gearing there is, in addition, a driven and a driving gear on the stud. A moment's consideration will be sufficient to show that in the instance of compound gearing, if we multiply together the pitch of the lead screw, the number of teeth in the gear on that screw and the number of teeth on the driven gear on the stud, the product will be the same as that obtained by multiplying together the pitch to be cut, the number of teeth on the spindle gear and the number of teeth on the driving gear on stud. Suppose we wish to cut 40 pitch. Select two driving gears, one for the spindle and the other for the stud. Say these gears are 20 for the spindle and 24 for the stud. Then $40 \times 20 \times 24 = 19200$. Place 80 gear on the lead screw; $6 \times 80 = 480$, and $19200 \div 480 = 40$ for driven gear on stud; $40 \times 20 \times 24 = 19200$ and $6 \times 80 \times 40 = 19200$.

104. H. L. asks: Will you please give instruction on how to line and put up shafting? A. Different mechanics have different ways of coming at this, and something will depend upon the construction of hangers and boxes, means of adjusting the latter, etc. Speaking in a general way and as indicating one plan of procedure, establish a line (a, in sketch) on the floor, one-half the diameter of the shaft to one side or the other from a line over which you want the center of shaft to lie when in position and adjusted. If the floor is of such a character or in such condition that you cannot establish a line on it, stretch a fine strong line (cord) in the position named and just above the floor. Some would prefer the stretched line in any event. For locating the hangers, adjust the boxes to a central position and clamp, one at a time, the hangers to the timbers to which they are to be bolted. Procure a short piece of iron three or four times the length of a box and turned to the size of the shaft, and place it as shown at b. Let fall two plumb bobs, as indicated in the sketch, and move the hanger till the points of both plumb bobs are exactly over the line, then bolt hanger to place. When the hangers are all bolted to place, put



in the shaft, with pulleys on, unless split pulleys are used, couple up and adjust the shaft by an accurate spirit level and a plumb bob. Instead of stretching the line as at a, it may be stretched above the plumb bob, as at c, the adjustment being correct when the line of the plumb bob just touches—but not so as to crowd it over—the stretched line. Instead of using the short piece b, it is a still better plan to use a length of the shafting to be erected, clamping up two hangers, passing the length of shafting through the boxes and adjusting by means of a plumb bob at each end of the length of shafting, the same as when the short piece with one hanger in place is employed. Bolt the two hangers to place, then clamp up another hanger, move the piece of shafting along till it enters its box, adjust and bolt the hanger to place, and so continue till all the hangers are bolted to place. The final adjustment is made as described, when the short piece of iron shown in the sketch is used. The short piece illustrates the way the plumb bob may be employed; this means of preliminary adjustment (by the use of the short piece) may, for various reasons, sometimes be advisable; but where a length of shafting, starting with two hangers, can be employed, it is better.

105. H. F. S. asks: What tests can an engineer make in an engine room to determine the relative value of different kinds of packing? A. Mr. Fred Collins, an erecting engineer of Providence R. I., suggests the following method when running with a Corliss engine: Use the two steam valves for testing purposes and before starting the test take out the valves and see that the

bearing is good and that they get the oil properly, and then examine the dash pots and see if they are in proper condition. Take two samples of packing and put one kind in one stuffing box and the other kind in the other box, leaving both loose enough so steam will blow around the stem as freely as though there were no packing there, and take two or three indicator cards with the steam blowing out; these cards to be indorsed with the steam pressure, revolutions, scale and number of drops of oil per minute, kind of packing, etc., and marked "No. 1." These cards would show by the sharpness of cut-off the minimum amount of friction on the valve stem from the packing. Then set the packing up so there is no leak, take more cards and compare the cut-off; and at regular intervals take cards until the packing is played out, being careful to have the conditions the same as for the No. 1 cards. A person proceeding in this way and taking cost of packing, time it lasts and labor to put in, take out, besides cleaning stuffing boxes, would probably be able to make a very good comparison of different packings.

106. B. F. writes: I wish to know what is meant by the term, "open and closed circuit work." I have often seen the term used in connection with batteries. A. In some kinds of electrical work, the current is used continuously, in others it is not. If the work is of a light character, such as is performed by batteries, it is called closed circuit work, if of the continuous type, and open circuit if of the intermittent type. Telegraph lines work on closed circuit, while telephones and call bells are of the open circuit variety. Some batteries are of such a character that they can deliver a small current continuously for a long time, ranging from several days to several months, according to the battery. These are called closed circuit batteries, because they are adapted for use in connection with closed circuit work. Other batteries are of such a character that they will deliver a very strong current for a short time, but if left in service continuously will soon run down until finally the current will be next to nothing. Some of these batteries will run down in a few minutes and others not under several hours. Such batteries are called open circuit batteries as they are adapted to open circuit work only. A dry battery is one in which the liquid is mixed with sawdust, plaster of paris or some other substance, so as to render it practically dry—that is, so that the liquid will not run out if it is turned upside down. Dry batteries are of the open circuit type, and are the best for such work, as they are clean and very cheap, selling as low as 25 cents.

107. L. E. D. writes: I wish to use a soft iron or steel disc for cutting metal cold. What should be the speed of such a disc, and will it do satisfactory work? *A*. Such discs are run at a peripheral speed of 50,000 to 80,000 feet per minute. Their work is not entirely satisfactory, though they are considerably used for some purposes. You may have fair success with them. A trial need not cost much. They are sometimes used at a speed of 25,000 feet, but the higher speed is the more satisfactory.

108. C. S. J. writes: Recently I made three sets of taps, with odd threads, such as could not be bought. There were three taps in a set. I cut the third or bottoming taps slightly tapering, the largest at the end. The foreman says this is not right; that they should be absolutely straight. We have both agreed to leave it to you which is right. Will you decide? A. We should make the bottoming tap just sensibly largest at the end.

109. L. C. asks: Can you explain why it is that lead, tin, solders, babbitt, etc., will prevent iron or steel from being welded if they are allowed to get into the fire? A. The fumes from the soft metal, which are really almost infinitely small particles of that metal set free by the heat of the fire; cover the surfaces to be welded, lightly, of course, but sufficiently to prevent that intimate contact necessary for a weld.

110. L. R. writes: I use a considerable number of wrought iron pieces ⅝ inch thick, which I want to case-harden quite deeply. This I do in a close iron box, very satisfactorily, but it leaves the pieces brittle. Is there any way that I can harden these pices about 1-16" or ⅛" deep, leaving the centre soft and the pices strong? A. Case harden the pieces as you are now doing, then anneal as you would anneal a piece of steel. Procure a suitable vessel, fill it nearly full of melted lead, and cover the surface with fine charcoal. Keep this lead over a forge fire, at a sufficiently high temperature; heat the pieces in this bath and plunge into cold water. The object of heating in the lead bath is that by so doing the outside is heated quickly, the core remaining cool, so that if the case-hardening extends through the inside will not be hardened. If the case-hardening extends only to a depth of 1-16" or so, you may succeed by heating in an ordinary open fire.

111. D. J. W. writes: "I have small quantities of screws which I should like to blue nicely. I do not have a sufficient amount of such work to pay for an elaborate arrangement, such as I have seen employed for the purpose, but I would like the work to look nice. Can you suggest a satisfactory way of bluing a few such pieces? I have tried heating them in a clean fire, and on a hot piece of iron, but no two will be alike in color; even the color will not be uniform. A. Procure an iron vessel of suitable size, fill nearly full of wood ashes, distribute the screws through the ashes, and heat the whole over a fire till the desired color is obtained, stirring them about while heating. Instead of the wood ashes, which if used, should be clean, you might use finely broken charcoal, or clean sharp sand will do very well. The heads of the screws should be nicely polished before bluing.

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FRESH FROM THE PRESS.

Lighting by Acetylene, by William E. Gibbs, M. E., 141 12mo pages, illustrated. D. Van Nostrand Co., New York. Price $1.50.

This is a timely work upon a subject that many people wish to know about, but concerning which there has as yet been very little literature from which a comprehensive idea of this new method of lighting could be obtained. The generation of acetylene is treated of, various types of generators being considered with practical considerations which have come under the observation of the author. A description of various forms of lamps and burners follows. The dangers of acetylene are fully explained and fire regulations in accordance with the New York Board of Fire Underwriters are given. There is also a list of United States patents on calcium carbide and acetylene apparatus.

The Traction Engine, its Use and Abuse, by James H. Maggard, revised and enlarged by an expert engineer. 128 pages, pocket size. David McKay, 1022 Market Street, Philadelphia, Pa. Price $1.00.

Traction engines so universally fall into the hands of men who are not only not good engineers, but who have absolutely no knowledge of mechanics and machinery that there is real need of a book in plain and simple terms giving directions for operating engines of this class. The author has omitted all theories and scientific calculations, intending the work, as he expresses it, for "rough and tumble engineers, who have everything in their favor to-day and to-morrow are in mud holes; who use well water to-day, creek water to-morrow and water from some stagnant pool the next day." To meet the requirements, therefore, the explanations are as clear as English can make them without the use of technical terms, and the book is devoted to the explanation of points that come up in every day practice, many of which would be obvious to an ordinary engineer.

ADVERTISING LITERATURE.

THE STANDARD SIZES FOR CATALOGS ARE 9 x 12, 6 x 9 AND 3½ x 6 INCHES. THE 6 x 9 IS RECOMMENDED, AS THIS SIZE IS MOST LIKELY TO BE PRESERVED.

Schuchardt & Schutte, machinery dealers of Berlin and Brussels, have sent us an illustrated circular containing views of their warerooms, which show a large line of American tools of various makes.

The W. Bingham Company, Cleveland, O., have issued a "handy book," vest pocket size, containing price list of hardware, cutlery and various manufacturers' supplies, with a number of pages of shop receipts and miscellaneous information for mechanics.

The William Powell Company, Cincinnati, O., manufacturers of lubricating devices, valves, etc., have issued a wall hanger of unique design showing a Powell's regrinding valve in the center, and around the outside a series of sketches, typifying the various countries in which these valves are used.

Thompson Electric Welding Company, Lynn, Mass. Catalogue of apparatus for electric welding, tempering, annealing, brazing, forging and shaping of metals; 32 pages, 6¾ by 8½ inches, illustrated.

The degree of prominence that is now being reached by this system of welding is forcibly brought to mind by the various illustrations in this catalogue, which show the wide extent to which electricity may be applied to welding.

THE BALL BEARING COMPANY, Boston, Mass. Catalogue of ball and roller bearings; 36 pages, 4½ by 7 inches.

Some of the new features of this catalogue over previous ones are the code system, the complete price list, the nomenclature of bearings for the convenience of customers in ordering and the added vertical bearings which are now listed.

THE AMERICAN STOKER COMPANY, Washington Life Building, New York. Descriptive catalogue of the American Stoker, illustrated, 6 x 9, standard size.

This catalogue, besides showing clearly the details of this stoker and explaining its mechanical construction, contains many illustrations showing the application of the stoker to various boiler plants. A number of tests are also quoted on plants on which the stoker is used.

C. W. HUNT COMPANY, 45 Broadway, New York. Catalogue of the Hunt automatic railway and also one of the Hunt cable railway for handling coal and merchandise, both 6¾ x 9¼ inches, illustrated.

FITCHBURG MACHINE WORKS, Fitchburg, Mass. Catalogue of metal working machinery; 109 pages, pocket size, illustrated.

This is a new and enlarged edition of these well known tools which has been issued in pocket form for several years past. Prominence is given to a description of the new gem lathe and some other new features. A few useful tables are added at the end of the catalogue.

MANUFACTURERS' NOTES.

MR. JULIUS KRAUS, late superintendent of the Ranken-Fritsch Foundry & Machine Company, St. Louis, Mo., has taken a similar position with the Ball Bearing Company, Boston, Mass., under General Manager Rogers.

WILLIAM BARAGWANATH & SON, manufacturers of feed water heaters, condensers, pumps, etc., write that they have been quite busy of late and have recently shipped twenty-five large pieces of apparatus to different firms, including 1000-h.p. condenser to the Fibre Box Company, Chicago, Ill. Two others of the same size to Armour & Company, Omaha; 1500-h.p. heater to Maxwell Bros., Chicago; two 800-h.p. heaters to Westinghouse, Church, Kerr & Company, and several others of 400 or 500-h.p. to other firms.

E. G. SMITH, manufacturer of mechanical tools, writes that he is selling quite a number of his "Which Way" levels, already described in "Machinery," to Europe, Australia and South America. He has generously sent one of these to the editor for use as a paper weight. It seems to be quite sensitive and well adapted for mechanics' use in setting up work or for other purposes in the shop where a large level is not desirable.

THE AMERICAN TOOL WORKS COMPANY, of Cincinnati, Ohio, report an increase in their orders from foreign countries. They have in the past week received orders through almost all of their European offices, chief among them being one through their office at St. Petersburg, for twenty-five engine lathes ranging in swing from 14" to 30".